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54. Dr. Miss Motabai Thanewala.
55. Dr. V. M. Ranade.
56. Muntazim Bahadur Miss Ahilya Bai Bhandarkar.
57. Rao Bahadur B. L. Modak.
58. Mr. N. R. Advani.
59. Mr. H. C. Sharma.
60. Mr. D. K. Bhave.
61. Mr. K. V. Kalevar.
62. Mr. Gendalal Champalal.
63. Mr. Gulab Chand Tongia.
64. Sardar N. K. Palshikar.
65. Dr. B. D. Mulye.
66. Lt.-Colonel D. de M. S. Fraser, I.A.
67. Mr. W. le B. Egerton, M.A., I.C.S.
68. Lt.-Colonel Sir James R. Roberts, Kt., C.I.E., I.M.S. (Retd.).
69. Major R. M. Lindsley.
70. Mr. P. G. Bree, I.C.S.
71. Mr. C. R. O. Robertson, I.P.
72. Miss L. Robertson.
73. Rev. A. A. Scott.
74 Rev. D. J. Davidson.
75. Captain R. G. E. W. Alban.
76. Lt.-Colonel M. A. Nicholson.
77. Mr. F. K. Jackson.
78. Mr. M. G. Salter, I.E.S.
79 Captain M. S. Harvey Jones.
80 Captain S. E. Tidy.
81 Mr. H. B. Goodridge.
82 Mr. G. B. Hutchinson.
83 Mr. Y. D. Wad.
84 Mr. G. C. Tambe.
85 Mr. A. N. Shrivastava.
86 Mr. S. C. Talesara.
87 Mr. Kuber Singh Chauhan.
88 Mr. K. M. Simlote.
89 Mr. Panse.
90 Rao Saheb A. G. Karnik.
91 Mr. N. D. Bhatia.
92 Mr. Bapu Mian S. Khan.
93 Mr. E. N. Cooper.
94 Mr. R. N. Zutshi.
95 Mr. B. L. Khanna.
96 Thakur Takhat Singhji Saheb.
97 Mr. Mohammad Anis.
98 Captain J. K. Kripalani.
99 Rai Bahadur Dr. S. H. Pandit.
100 Rao Saheb V. K. Phadke.
101 Mr. M. A. Sogu.
102 Major D. K. Ardeshir.
103 Captain S. K. Mukerji.
104 Dr. G. D. Khandekar.
105 Dr. J. D. Dundas.
106 Dr. G. A. Kher.
107 Dr. B. N. Desai.
108 Captain H. B. Gokhale.
109 Mr. D. R. Lahiri.
110 Mr. K. A. Patwardhan.
111 Mr. Vardharanjan.

SPECIAL OFFICERS OF THE LOCAL RECEPTION COMMITTEE:

DEPARTMENTS.	OFFICERS.
Sectional Meetings and Popular Lectures	Mr. F. K. Jackson.
Residence	Mr. K. M. Bapna.
Guide Book	Rev. A. A. Scott.
Exhibition	Col. J. R. J. Tyrrell.
Entertainment	Miss I. N. Bhagwat.
Excursions	Col. M. A. Nicholson.
Volunteers	Mr. V. G. Barpute. Mr. K. L. Bordia.
Printing	Mr. W. G. Urdhwareshe.
Conveyances	Mr. J. C. Mukerji.
Opening Ceremony	Mr. L. C. Dhariwal.

General.

The Twenty-third meeting of the Indian Science Congress Association was held at Indore from January 2nd to 8th, 1936.

The inaugural meeting was held on Thursday, January 2nd, 1936 at 5-30 P.M. in the King Edward Hall, Indore City, in the presence of the Patron, His Highness Maharajadhiraj Raj Rajeshwar Sawai Shree Yeshwant Rao Holkar Bahadur, G.C.I.E., Maharaja of Indore. Dr. P. Basu, M.A., Ph.D., B.L., Principal, Holkar College, Indore, Chairman of the Reception Committee welcomed the delegates in a speech and requested His Highness the Maharaja of Indore to open the Congress. His Highness opened the Congress with a speech and then the President of the Congress Rai Sir U. N. Brahmachari Bahadur, Kt., M.A., M.D., Ph.D., F.S.M.F., F.A.S.B., F.N.I. delivered his address.

THE SECTIONAL PRESIDENTIAL ADDRESSES WERE DELIVERED AS FOLLOWS :—

FRIDAY, *3rd January*, 10 A.M., Agriculture ; 11 A.M., Medical and Veterinary Research ; 12 NOON, Psychology.

SATURDAY, *4th January*, 10 A.M., Chemistry ; 11 A.M., Physiology ; 12 NOON, Zoology.

MONDAY, *6th January*, 10 A.M., Mathematics and Physics ; 11 A.M., Geology and Geography ; 12 NOON, Botany.

TUESDAY, *7th January*, 10 A.M., Anthropology.

SYMPOSIA AND JOINT MEETINGS OF SECTIONS WERE HELD AS FOLLOWS :—

FRIDAY, *3rd January*, 11-30 A.M.–1 P.M., Discussion on 'The Scope of Preparation of Fine Chemicals in India', Section of Chemistry.

SATURDAY, *4th January*, 11 A.M.–1 P.M., Joint Meeting of the Sections of Agriculture and Medical and Veterinary Research to discuss 'The Making of Humus, and its Application.'

MONDAY, *6th January*, 11 A.M.–1 P.M., Joint Meeting of the Sections of Medical and Veterinary Research and Physiology to discuss 'The Problem of Nutrition in India'. 11-30 A.M.–1 P.M., Discussion on 'Utilization of Molasses', Section of Chemistry.

TUESDAY, *7th January*, 10 A.M., Discussion on 'The Classification of the Archæan Rocks in India,' Section of Geology

and Geography. 10 A.M.–1 P.M., Joint Meeting of the Sections of Chemistry and Mathematics and Physics to discuss 'The Structure of Molecules'.

WEDNESDAY, *8th January*, 10 A.M., Joint Meeting of the Sections of Botany and Zoology to discuss 'Biology Teaching in Secondary Schools'.

POPULAR LECTURES WERE DELIVERED AS FOLLOWS :—

FRIDAY, *3rd January*, 6-30 P.M., 'Science in Service of Indian Agriculture' by Sir B. C. Burt, Kt., C.I.E., M.B.E., P.Sc., F.N.I., I.A.S., Vice-Chairman, Imperial Council of Agricultural Research, New Delhi.

SATURDAY, *4th January*, 6-30 P.M., 'Some Aspects of Indian Weather' by Dr. B. N. Desai, B.A., LL.B., M.Sc., Ph.D., F.R.S.E., Meteorological Department, Karachi.

MONDAY, *6th January*, 6-30 P.M., 'The Reign of Chance in Present Day Science' by Dr. D. S. Kothari, M.Sc., Ph.D. (Cantab), Head of the Physics Department, University of Delhi.

THE FOLLOWING FUNCTIONS AND ENTERTAINMENTS WERE HELD IN HONOUR OF THE MEMBERS OF THE INDIAN SCIENCE CONGRESS :—

MONDAY, *6th January*, 9-30 P.M., Variety Entertainments.

TUESDAY, *7th January*, 4-30 P.M., Garden party given by His Highness the Maharaja of Indore.

THE FOLLOWING VISITS AND EXCURSIONS WERE ARRANGED FOR MEMBERS OF THE INDIAN SCIENCE CONGRESS :—

FRIDAY, *3rd January*, 2 P.M.–4-30 P.M., Excursion to the Institute of Plant Industry.

SUNDAY, *5th January*, Whole-day Excursions to—

(1) Mandu,
(2) Maheshwar,
(3) Onkareshwar,
(4) Ujjain.

MONDAY, *6th January*, 3 P.M., Excursion to Yeshwant Sagar Water Works.

TUESDAY, *7th January*, 2 P.M.–4 P.M., Excursions.

WEDNESDAY, *8th January*, 2 P.M.–4 P.M., Excursions.

THE SECTIONAL COMMITTEES met at 2 P.M. on Thursday, 2nd January, 1936.

THE COUNCIL met at 3 P.M., on Thursday, 2nd January, 1936.

THE EXECUTIVE COMMITTEE met at 12 NOON on Thursday, 2nd January (special meeting), and at 1-45 P.M. on Friday, 3rd January, 1936.

THE GENERAL COMMITTEE met at 1-45 P.M. on Monday, 6th January, 1936.

Opening Proceedings.

The Twenty-third Session of the Indian Science Congress was opened on Thursday, January 2nd, 1936 at 5-30 P.M. by His Highness the Maharaja of Indore in the King Edward Hall, Indore City, in the presence of a large gathering of delegates and visitors. The Chairman of the Local Reception Committee, Dr. P. Basu, welcomed the delegates and visitors in a speech as follows :—

'YOUR HIGHNESSES, LADIES, AND GENTLEMEN,

As Chairman of the Reception Committee of the Twenty-third Session of the Indian Science Congress it gives me great pleasure to extend a hearty welcome to the delegates of the Congress assembled here to-night. They represent the best men of science in India, many of whom have achieved distinction in helping to extend the bounds of knowledge in various branches of scientific study and several of whom have established for themselves worldwide reputation for original research. I should not miss this opportunity of letting them know that Indore justly feels proud of having the honour of welcoming such distinguished scientists and providing a forum for them to discuss important scientific discoveries to which they have so ably contributed.

Ladies and gentlemen, when I talk of scientific discoveries I wonder how many of us present here fully realize the astonishing and bewildering changes which science has introduced into our ideas about the nature and structure of the universe of which we form a part. I am not a scientist nor even a student of science. But as average laymen we cannot but have an interest in what is going on around us. Scientific discoveries react upon the laymen whose ideas may not be quite accurate but which have or ought to have an interest even for the technical man. Science has made many things familiar to us and introduced vast changes in our ways of living. The exact nature of these things is yet unknown and their ultimate structure is yet the engrossing subject of research. But science has been grappling with these problems with greater success and ever increasing zest. Although the achievement of science has been extraordinarily great in the present century yet the final mystery has so far eluded its grasp. Pandora's box is being attacked with increasing success and new wonders are being revealed to us almost every day. To the ordinary man unacquainted alike with the highly specialized subjects of scientific study and with the evolution of the extremely delicate technique which is involved in scientific experiments the conclusions of physical

sciences would appear to be incredible but for the wide and numerous confirmations by their practical application in the affairs of daily life. The practical results of conversion of sound into electricity and its reflection back from the ionosphere as seen in broadcasting, of ultra-violet and infra-red rays for therapeutic and photographic purposes, and of radium in various medical uses as also in accurately estimating the age of the earth from the helium and lead content of deposits have immense value to all human beings.

Physics with its complex mathematical formulæ has transported us to a stage where the new idea regarding the universe and its constituent factors is utterly strange to the traditional picture of the universe as it appears to the senses. On the one hand it has discovered the operation of the basic forces of the universe and tells us that it is finite but expanding in space, if space has been left with any meaning now, and that yet in the geodesic revolutions it is infinite. It informs us that we are being continuously bombarded by the mysterious cosmic rays, the source, origin and nature of which are as yet only hazily comprehended but which obviously have tremendous influence on the life and conditions on earth. Daring but fruitful experiments have been successfully carried out by which, in quest of nature's secrets, man has ascended fourteen miles above the surface of the earth. The imaginative stories of H. G. Wells which delighted us in our childhood no longer appear as fiction but threaten to be less romantic than the proven facts of the physicist.

Looking, on the other hand, to the structure of the constituent element of the universe physics tells us that matter is nothing but frozen energy and that the much familiar yet mysterious ray is probably the basic factor of which the universe is composed. It is yet a moot point whether this basic factor is merely a wave or a particle or both. The old philosophical question whether we exist in the ultimate sense is raised again by the work of the scientist and we are no nearer the end of our perplexity when we are told that what we see are probably point events in a geometrical configuration, mere depressions in a vortex of energy.

For long we knew matter as composed of elements and the elements as composed ultimately of atoms which were indivisible. Lockyer's experiments with variations in the spectra of heavenly bodies and the law of periodicity raised doubts and indicated a more complex constitution of atoms. Even to-day the largest atom remains invisible even under the most powerful microscope. But it has been split up into parts which are a fraction in several thousands of the lightest atom. These are of course invisible but the ingenuity of the scientist has had photographs of the passage of electron and revealed its behaviour as electricity by photographic picture of its deflection under the magnet. Without

understanding the technical arguments one can read with pleasure the romance of proton, electron, and photon and wonder with the scientist whether we have yet reached the core of the originally indivisible atom.

In biology no less wonders have been achieved although they are less widely known. Darwinian theory of evolution has undergone considerable modification. Heredity and environment have been studied in greater detail with reference to variation in the species. A new science of ecology has grown, the application of which is bound to revolutionize man's existence on earth. Whether in studying the extension, modification, or disappearance of species in plant or animal life ecology must form the basic study in future. Its practical application in many of the south sea islands has helped man to live more comfortably over wide areas.

In heredity the old traditional idea of the mixture of blood has long been exploded and now we are right in the midst of the intricacies of hereditary transmission of characteristics as the scientist has passed from microscopic chromosomes to ultra-microscopic genes. They not only remain constant for the species but determine the minutest details of what are transmitted from the parent to the offspring. Now we understand the reason why the great improvement in medical science has been unable to deal with hereditary diseases and has had to content itself mostly with what may be called contact diseases. Nature's protective measure for genes has remained unpenetrated although its working through the principle of dominant and recessive characteristics has been revealed. The progress of the science of eugenics is based wholly on the understanding and application of this principle.

Another momentous discovery of biology is the function of the ductless glands. As a boy I read in my text-book that these were remnants of organs which in the course of evolution had lost their functions and had thus been reduced to mere accretions. To-day it is known as a certainty that hormones have a dominating influence on the whole life including mental temperament and character. Besides the gonad and adrenal glands the importance of the thyroid gland has been studied with some detail. But the pituitary gland which is just below the brain is suspected to be the most important of all glands, determining and co-ordinating the working of the body as a whole. Indeed it is probable that we shall soon start saying that the pituitary gland is life itself. One hundred experts from seventeen countries met at London last month specially to study this particular gland. There is no doubt that medical treatment will undergo a revolution if the exact functions of these glands can be properly understood and their working controlled. In a sense the discovery of insulin has made man independent of the islets of Langerhans.

The borderland of physiology and psychology is being successfully attacked, and mental phenomena are being scientifically studied as manifestations of the individual as a whole. Psycho-analysis has studied more deeply than any other science the working of human mind as manifested in types of thought and conduct. The explosive effect of the subconscious mind has for the first time explained the impulsive aspect of human conduct. As in Darwinian theory of evolution so in Freudian theory of libido, too much emphasis is found to have been given to one aspect of the cause. Inhibition by repression in general rather than of one particular type is now known to be the dominating force in the subconscious mind. The main problem which now remains to be solved is the development of the technique of interpreting the manifestation of the subconscious mind as this expression is in terms of the cruder symbols by which the individual had been used to think or express himself in his childhood. The manifestation naturally varies according to the individual and more according to the social atmosphere through which he passed in his childhood. But the problem is being successfully attacked where details of the individual's early history are well known. There is no doubt that in course of time our ideas both of education and of treatment of the delinquent and the criminal will undergo fundamental changes.

The so-called spiritual phenomena are being studied experimentally and have, in several cases, been found to be mental reactions to the environment in conjunction with the subconscious mind. The simple psychological reactions of man in conditioning, de-conditioning, and re-conditioning of reflexes have all been demonstrated in animals in the famous experiments of Pavlov. Similar experiments by Watson have been successfully performed with the human child and the simpler phenomena of the child mind have been found to be very similar to those of Pavlov's dogs. We need not yet trouble ourselves with the more distant implications of behaviourism or impressionism which as a side issue has recently attacked the domain of man's æsthetic expressions. But there is no doubt that psycho-analysis has progressed so far that it expects soon to be set up as a more or less exact science. The implication of this to man's life is indeed great, much greater than even the scientist realizes. It can be found in some modern tendencies which appear to be somewhat pretentious as can be seen from the clinic of psycho-analysis, in one of the reputed centres of Europe, which purports to cure a woman of the mental disease called jealousy.

It is not necessary for me further to pursue the picture which is growing in the mind of the average layman as a result of recent scientific discoveries. In less than a century conditions of human living have entirely changed. The means of locomotion differed only in degree and not in kind when Napoleon overran Europe and when Alexander or Cæsar had marched out

before him. The means of warfare in Napoleon's time did not differ in kind from those at the disposal of Charles V. The man of middle nineteenth century consumed mainly what his neighbourhood could produce. To-day the aspect of things is entirely changed. Mechanization of industries has immensely increased the materials at the disposal of man. The old means of locomotion have been largely displaced by the machine. Electricity and oil have introduced vast changes. Distance by land, air, and sea has been killed and the world has been knit together more closely than what neighbouring places used to be half a century ago. Life has been made more comfortable and the peasant to-day lives in greater affluence than the king of the middle ages. Amenities of life are continually growing. Human life is being saved in scores of millions through corporate measures for health and hygiene. In the applied sciences like industries, engineering, and medicine tremendous progress has been made. Life to-day is healthier, more efficient, and more comfortable.

In ordinary social life the increased amenities of life, rapid means of communication, economic factors of a novel type, and the charm and dignity of life in its material plane have been introduced with the application of scientific principles to the affairs of daily life. The net result is that the old machinery of social life has been suddenly thrown out of gear and a new one has not been set up. There is thus a maladjustment in human personality which is yet to find its level and adjust itself to its new environment.

There is a subtle aspect in which the social dissolution has been inaugurated by science. The proverb that the old order changeth yielding place to new was an euphemism before, for man's social organization was conservative to a high degree. Certain social factors have appeared to break down this conservatism. But more in this direction has been the work of scientific discoveries than that of any other single force. Up to the nineteenth century science battled with religion and was the worse off in the affray. After Huxley science gave up the battle in order to pursue more serious things but scientific method and scientific ideas have demolished the old religious and moral ideas dominated by a personal god. In this respect religion has failed to develop and fill the gap left by science. Copernican conception of the universe dislodged our earth from the central position which it had occupied under the Ptolemic system. In spiritual matters man still remains the Ptolemic outlook and thinks himself to be the pivot of the universe. Thus he allows himself to remain the central point of interest and care at the hands of a beneficent god. This is due to man's vanity in considering himself as the most important item of creation. Science has proved that earth is a minor factor in the solar universe, the solar universe an ordinary part of the galactic system, and the galactic system is only one of millions and millions of such systems. Science has

also proved that the emergence of planets from a star is due to a conjuncture of exceptional circumstances, the freak emergence of life a still rarer exception, and the earth is only a dead spec of dust out of the ashes. If there is a god watching in his laboratory, is he anxious for the little ant that gads about in the discarded ash ? Is not life only a bye-product in that laboratory ? Religion has failed to rationalize itself in this direction.

For long scientific ideas have been isolated from religion by habit, tradition, and inertia. But scientific method is proving more potent than even scientific facts. The method of doubt and of conviction by positive proof, which science has borrowed from philosophy and the technique of which it has so well developed, was irreverently thrust into spiritual matters and has penetrated every branch of thought. Thus the strongest factor, which held society together, compelled man to behave toward himself, to his fellow-men, and even to the animal kingdom, which modelled thought, directed emotions, and controlled action, has been considerably weakened, leaving social expediency as the only guide to action and social decorum the only restraint on emotional expression.

Beyond and above social adjustment there is another and a more subtle adjustment which remains to be made. Such an adjustment was never achieved in the past except in rare individual cases. This is the balance of human personality. If this is ever achieved it will be by science itself as well as its method when applied to the study of human psychology and human emotions. Biology, experimental psychology, and psycho-analysis will all be requisitioned in the service. Knowledge of the laws of human mind must be applied in order to develop this equilibrium. Human mind in its existing conflict between the conscious and the subconscious as also in its more elemental forces vaguely called instincts must be analysed and co-ordinated. If there is such a thing as an urge in human life, what the great philosopher calls the *elân vital*, the application of the laws of the relevant sciences must be in accord with and in the same direction as life's urge. Although this urge may be fundamentally the same in all men, indeed in all life, yet its natural lines of development cannot be the same for all. Its extent and direction are bound to vary at least with heredity and environment if not with every individual unit. This must be properly studied and scientific measures adapted to each type. In order to be able to do so a condition precedent is that life and its subtler forces must be studied by the same dispassionate and objective method which science has applied to the study of the external world. This is more difficult than in the physical sciences, for here the researcher will have to battle with human passions and emotions which do not intrude into scientific studies and the existence of which acts as an obstacle to the application of scientific method. But if the science of life is to

develop into a real science where forces are to be studied as they are in the physical sciences like physics or chemistry and if the application of conclusions is to be as deliberate as in the applied sciences like medicine or engineering, the equilibrium in the developed human personality can only be achieved by patient work pursuing objective laws and eleminating all subjective aberrations. This is vital to man's future, for in the absence of such adjustment leading to intellectual and emotional balance he, like Faust, may win the world and yet be damned. Biology and psychology seem to have already started on the way. Their conclusions must be applied by medical science and education, of which the latter is hardly conscious of its function in this direction.

One point must be emphasized before it is possible to develop a real science of life. All human knowledge is progressing by specialization. This is necessary as a sort of division of labour; also for concentrating attention along particular lines. The product of man's intellectual labour has immensely multiplied as a result of high specialization Now it seems impossible that any one man will ever know the various branches and subdivisions of human knowledge. The days of encyclopædists appear to have gone for ever and no body tries to gain a comprehensive insight into all the branches of human knowledge. But if a real science of life is to be developed and fruitfully applied toward efficient living the present state of leaving matters to chance must be replaced by deliberate planning. This can be done only when the preliminary work of co-ordinating and dovetailing the conclusions of the large variety of specialized study has been successfully attempted. My impression is that this has not only not been tried but its importance for the future of man has not been realized. This is not the work of the scientist nor, as it was once supposed, that of the philosopher. But this is a desideratum without which the application of scientific discoveries to human life must to a great extent remain ineffectual.

The scientist pursues knowledge for its own sake. There is no doubt that this is a high ideal, one of the highest that humanity has ever attempted to realize. But his work has also a practical bearing both from the cultural point of view and from that of greater efficiency. Without this the leisure, expenses, and facilities which must be provided to the scientist in an increasing measure cannot be guaranteed. Also as a pragmatic end the welfare of man, both material and cultural, is not a negligible objective to be pursued. I hope that attention will be directed to this aspect of the question and that the necessary technique for developing a comprehensive science of knowledge and its successful application for the betterment of the human species will be worked out in the same way as specialization has been pursued in all branches of human knowledge. This

cannot be undertaken by the layman but must be done by men who have been highly trained in the scientific method. At present the whole work is left to private enterprise working for personal profit. This is not only insufficient but dangerous to society. In any case it leads to great wastage of men and materials and does not utilize the opportunities as well as they might have been. I believe that the spirit of adventure found in the pursuit of knowledge for its own sake will find equally wide scope in the pursuit of co-ordinating this variety of knowledge into one whole and applying it for the benefit of humanity.

There is a general feeling that the layman does not fully appreciate the work of the technical man of science and tries always to calculate things in terms of practical result. This is no doubt true but only to a limited extent. It is human nature to be more interested in what directly concerns it. Yet the opportunities which society offers to the scientist for carrying on his work have materially helped him in the pursuit of knowledge. To rouse further the layman's interest and make him offer greater opportunities to the scientist for carrying on his work little has been done by the scientist himself. For half a century after Huxley scientists have done little to popularize their discoveries and make them available in forms which will be understood by the average layman and which will interest him. In fact, even the expert in one specialized branch cannot always follow the work of another specialist in an allied branch of science. In recent years the work has again been taken up by men like Jeans and Eddington.

Ladies and gentlemen, I am not a scientist but I claim to be an average layman. I remember that for years I tried in vain to get at some popular exposition of Einstein's theory of relativity and what it meant. For more than ten years I failed to get at any popular literature on the subject which would help me to pursue the topic a little beyond the most elementary stage. A large sum of money was given as a prize in America to the author who would write the best book on the theory of relativity which would be understood by a man who had read no mathematics or any other technical science. I got that book but was out of my depths within the first ten pages Then Eddington delivered that lecture which is so familiar to the layman and which is so dear to him as an introduction. Since then he and others have written more technical things which can be followed with the help of that introduction book. The point that I want to make is that the scientist has a duty in popularizing his work in order to spread both culture and interest in his work. This can be done by the scientist alone and by no body else. My humble request to the great body of scientists assembled here to-night is that they may give some thought to us laymen and help us occasionally to light our small lamps from the dazzling torches which they carry about with them. We are

not presumptuous to aspire to enter the highly ionized sphere of the scientist's activity but let him permit us to receive a few rays of his light of knowledge penetrating into the dense atmosphere in which it is our lot to live and move and have our being.

Ladies and gentlemen, I fear that I have now exhausted your patience. But I hope that I have not bored you more than what it is customary for a Chairman of the Reception Committee. He seems to be the only man who, on an occasion like this, has the privilege of giving expression to the layman's feelings before the technical experts. I have now only one pleasant duty to perform. His Highness the Maharaja Holkar has kindly consented to open the Twenty-third Session of the Indian Science Congress. We know the number of social engagements which he has got to keep and in which he plays a gracious part. We are, therefore, grateful to him for agreeing to come here to-night. I now request His Highness to declare this Congress open.'

His Highness the Maharaja of Indore, as Patron of the Congress, then addressed the meeting as follows :—

, LADIES AND GENTLEMEN,

A group of distinguished scientists have assembled here to discuss the work they have been doing during the past year and I need scarcely say how much pleasure it gives me to greet them in my Capital. I am a layman in scientific matters and I know that you will not expect me to make a show of an erudition that I do not possess ; but I am also the Ruler of a State, placed by destiny in charge of the welfare of lakhs of people, and any thing that furthers the welfare of mankind naturally arouses my keenest interest. It is, therefore, in the practical results of scientific research and their application to the improvement of man's everyday life that I find to-day my greatest enthusiasm.

All the numerous branches of scientific activity medicine, agriculture, veterinary work, psychology, psycho-analysis, metallurgy, mathematics—which we label together under the general term " science " can and should have this common meeting-place, the betterment of human life. Science can do so much to render men and women happier and healthier and I would like to remark upon a few of the ways open to us by which we can take advantage of modern scientific discoveries. India's greatest problem is her poverty ; add to this the vast size of the Indian continent and the fact that it is still, despite the industrialization of a few centres, almost entirely an agricultural nation, and one at once realizes how greatly the application of modern methods, of the results, in short, of scientific research and discovery, can help us in the solution of that problem. The difficulties of distribution have largely been removed by the railway and the lorry ; it is rather the problems of increasing the yield of the soil and of using our vast natural mineral resources

that demand the most strenuous efforts of our scientists and the application of the results of their labours. For the proper tilling of the soil, the sowing of scientifically tested seed, and the thorough exploitation of the wealth lying beneath the ground can and one day ought to change India from a poor country to one of the richest countries in the world. Our scientific experts are not yet organized as they might be to this end and one thing which will, I think, have to be done before we can rely upon an adequate supply of trained men to fill gaps and to carry on an ever-expanding propaganda is to raise the standard of our university degrees to parity with those of London and of other famous places of learning. We have a great many famous scientists—Sir Jagadish Chandra Bose, Sir C. V. Raman, our President here to-day, to mention but a few—but are our young men receiving such training as will enable them to take the place of these great scientists when they have passed on?

To return to the problems before us, in many places—including, I am happy to say, Indore—efforts are being made to improve agriculture, to improve not only the Kisans' implements but more especially the quality of the crops he sows; and our scientists have made some notable contributions to man's knowledge of plant life. Moreover, science has rendered possible a health and hygiene on the part of the common people that was unthought-of fifty years ago. Medicine, both preventive and curative, has advanced rapidly, and in general the scientific study of economics and social behaviour has improved almost beyond belief the possibility of our one day seeing a whole nation of healthy men and women. It is not, Ladies and Gentlemen, lack of knowledge from which we suffer; our problem lies mainly in the dissemination of the knowledge we have. India is so vast, the habits of its people so conservative, and their poverty so heart-breaking, that it is extremely difficult for the few that have the necessary knowledge to pass it on, whether they are the scientists themselves, or governments, or public-spirited individuals. The Co-operative Movement, in which I take a keen interest in Indore, is capable, when properly developed, of being used as an instrument for the education of the people in scientific matters and also as an instrument for the supply and distribution of scientifically prepared seeds and implements—as I understand is being done in Mysore; while for the dissemination of knowledge itself the U.P. Government have been trying out a scheme which greatly interests me—I refer to that Government's efforts to educate the peasant not only in agricultural matters and methods but also in hygiene and in elementary medical attention by means of a cinema which, accompanied by experts, tours the villages on a lorry. In the Punjab, I believe, some progress is being made in the education of the villager by means of wireless. All these are examples of the application of modern scientific discoveries to

the improvement of man's lot; and I feel sure that this practical side of science is one that you realize as much as I do, for I see that your President this year is Sir Upendranath Brahmachari, who is not only a distinguished medical practitioner of long experience but also a research worker of no mean attainments. In this same field of practical science I must add a word of welcome to the National Institute of Science—an All-India organization of which we have stood for long in great need. I am more than glad that at last it has come into existence and I am delighted that its first meeting should be held here in my Capital. Moreover, it is fortunate in having as its first President Sir Lewis Fermor, who is in charge of the Geological Survey of India, a Department of the greatest practical importance in extending knowledge of our natural resources.

You may perhaps feel that I have over-stressed the practical side of scientific work; but that side, Ladies and Gentlemen, from the points of view both of the peasantry and of the Ruler of a State, must always take pride of place. Nevertheless, the practical application of scientific discoveries is two-edged; while men of goodwill are straining every nerve of science in the cause of humanity, others are degrading the great achievements of that same science to the destruction of their fellowmen. The numerous armed conflicts at present raging in many parts of the world are essentially a battle between destructive science and an uneducated peasantry. This is a problem for which, I confess, I see no solution; yet for the salvation of mankind it is essential that science should be an instrument of construction and of peace, and its lethal, destructive potentialities should be controlled and checked in the interests of humanity.

Finally, I see a danger to which we in India are exposed; we are in danger of losing our own great heritage in this newer science that we have taken from the West. We have an Ayurvedic system of medicine which should be studied in the light of modern scientific principles. Up to the present, except for a few isolated workers, the scientific world has held rather disdainfully aloof from India's indigenous medicine. This is a great pity; why should scientists not keep what is good in it and reject only those parts which are proven bad or faulty? I commend this point to your attention, Ladies and Gentlemen. Moreover, medicine apart, India has a philosophy and a metaphysics of her own. For centuries she has enriched herself in philosophy, in the development of the mind and the soul; to-day she is beginning to enrich herself scientifically, in the development of the intellect. Now there are things that so far have proved incapable of intellectual explanation, of scientific test, even, perhaps, of intellectual or scientific comprehension. India's practical combination of psychology and physiology in what is known as the practice of Yog has been proved to be capable of results in improving the strength of the body to say

nothing of the spiritual achievements to which it lays claim. Surely this can be rescued from ignorant hands and be scientifically examined. It was a practical thing centuries before the West began playing with hypnotism and allied phenomena of the sub-conscious mind. Yet these things exist and the greatest scientists of the West are beginning to find that something more that " pure " science is required to explain them ; it is said, indeed, that the West is turning to the East for help in these matters. And may it not be that the explanation is to be found for these curious phenomena of the mind and spirit in our own Indian philosophy ? Ought we not to combine our enormous heritage of philosophy and metaphysics with this comparatively new science that we have taken from the West ? I fear that, as the 19th century in Europe lost God in the laboratory—if I may put it in that way—so we may lose all that is good in our ancient heritage owing to our over enthusiasm for the new. In a combination, on truly scientific lines, of the good of both I see a meeting-ground common to all humanity, standing whereon it will no longer be possible for men to say that " East is East and West is West and never the twain shall meet."

Ladies and Gentlemen, I now have great pleasure in declaring this Congress open and in wishing it all success in the great work it has undertaken.'

Presidential Address.

Congress President:—Sir U. N. Brahmachari, Kt., M.A., M.D., Ph.D., F.S.M.F., F.A.S.B., F.N.I.

Presidential Address.

THE RÔLE OF SCIENCE IN THE RECENT PROGRESS OF MEDICINE.

Your Highness, Ladies, and Gentlemen,

We happily meet this year at Indore in the famous land of Mālava, watered by the beautiful Siprā. Not far from here are the sites of the sacred cities of Māhiṣmatī, Ujjayinī and Dhārā, whose names conjure up glorious visions of the past. The town of Maheswar is connected with the hallowed memory of the saintly Ahalyā Bāī, an illustrious ruler of the Indore State, whose piety and generosity are even today a household word throughout India. Ujjayinī was a famous seat of learning in the olden times.

In the fitness of things the Indian Science Congress has been invited to hold one of its sessions in this historic place, thanks to the hospitality of its most enlightened ruler, His Highness Maharajadhiraj Raj Rajeshwar Sawai Shree Yeshwant Rao Holkar Bahadur, Maharaja of Indore. In the annals of Indian history, the Holkars hold an honoured place for their achievements in the field of arms and of peace.

Under the able guidance of His Highness the city of Indore now ranks amongst the great industrial and highly cultured cities of India. It is an important educational centre with an excellent plant research institute, many high schools and colleges, an excellent institution for the training of the sons of Chiefs and a medical school, and with palaces and beautiful gardens. Indore must feel proud that His Highness has recently introduced so many reforms in his State, has given her a magnificent aerodrome with a splendid landing ground, and has inaugurated many beneficial schemes, such as, geological and mining surveys, vocational education and development of new industries and encouragement of industrial research. Within a few miles of the city are the great waterworks of Badarkha with the largest syphon system in the world which, I understand, is an extraordinary feat of engineering skill. By the generosity of His Highness and the co-operation of his officers, hosts and guests have met today under a happy augury of success and we have every reason to congratulate ourselves on his gracious hospitality and kindness.

In rising to address you at this annual meeting of your Congress, I feel I am hardly worthy to occupy an office which is associated with the names of those with whom I cannot compete in greatness. A few years ago, Lord Rutherford stated at a meeting of medical men that the hopes of the world rested upon their success and ever-growing usefulness. Aviation, wireless, and television have now been accomplished, but one thing still left to wish for, Lord Rutherford very truly remarked, was long life and health, and it was the medical profession with whom it lay to give that guerdon to humanity. For 'Happiness lies, first of all, in health'.

> 'O blessed health! thou art above all gold and treasure . . . . He that has thee has little more to wish for and he that is so wretched as to want thee, wants everything with thee.'

Standing here today as your president, I think I should show no partiality towards the science of medicine by choosing it for my address because I happen to be a medical man. As it is customary in the annual meetings of scientific societies for the president to refer to the recent advances in science and as the progress as well as the future achievements of medicine, which is concerned with the preservation and restoration of normal activity of living matter in the human machine, depends to a great extent upon the help that she has had and may yet get from the sciences that you profess, you would perhaps expect me, as far as practicable within the time at my disposal and as far as lies in my power, to give a review of the important contributions made by some of your sciences in recent times towards the advancement of medicine. I shall take cognisance of our recent knowledge of some aspects of living matter, as medicine is intimately connected with life, and I shall refer to some recent facts revealed by your sciences which may apparently have no particular relation to medicine in the present day, but may be of medical interest in the future.

The future happiness of mankind depends on the solution of the problems of life. These problems are much more complicated than those of physics and chemistry, and still more is this the case with the science of medicine, which deals with the pathological aspects of living matter. I shall probably be able to say nothing that is new, but presentation, from a different view point, of things already heard may perhaps be profitable.

BIOCHEMISTRY.

I shall begin by saying a few words about our present day conception of dietetics and nutrition.

As a matter of the most vital concern in nation-building, the problem of nutrition demands very careful consideration by

statesmen and scientists alike, more so due to the fact, as has been recently observed, that a great part of the world's population is not consuming the necessary food stuff. An eminent Swiss authority predicts the decay of civilization unless there is a fundamental revision of the people's diet.

Dietetics and nutrition. Vitamins.

It has been stated that the function of nutrition is probably the centre of medicine from a medical point of view, and that the proper dietary of man is a most important subject for the maintenance of health and prevention of disease. As has been observed by Hopkins, during the whole history the needs of nutrition and the kind and amount of food geographically available have played a great part in determining the destinies of races. It has been stated 'tell me what you eat and I shall tell you what you are.' 'Man's place in future history will depend in no small degree on the food he eats.' Nutrition is one of the essential functions of life and its value cannot be too much emphasized.

Up to 20 years ago, the reign of calories was supreme in the field of nutrition, and it was held that if the proper amount of energy required for maintaining nutritional equilibrium could be worked out in terms of calories, then the last word would be said about the problem of nutrition. But it has now come to be recognized that certain substances that had eluded detection in the past, are indispensable in our dietary for the normal activity of the tissue cells and the prevention of certain diseased conditions. Further the study of the problem of nutrition has increased in recent times from the quantitative to the qualitative standpoint, especially with respect to the proteins.

Though it was long known that diseases like beri-beri were due to deficiency in the food of certain substances of unknown chemical nature, it was Hopkins who made in 1912 the monumental discovery of the value of the 'accessory food factors', or the 'vitamines' as they were termed by Casimir Funk, in the maintenance of normal functional activity and growth. The progress of research upon the nature, distribution and functions of vitamins has been very intense in recent days. To attempt to summarize all that is known about them is beyond the limits of my lecture. The discovery of vitamins has led to the relief of a considerable amount of suffering and disablement that is particularly true in regard to rickets. Many of them are simple chemical substances and it is possible that each of them possesses a strict specificity in its action, though lack of more than one vitamin may be responsible for the causation of the complex phenomena manifested by disease.

The function of vitamins and the pathological lesions due to their deficiency are known to those among you, who are biochemists or who belong to the medical profession. I shall not discuss them here.

It is possible that the lack of vitamins does not play such an important part in the causation of disease as has been claimed by some observers and that the symptoms following a deficiency of certain vitamins may be attributed to a disturbance in the gastro-intestinal canal. It is realized today that the processes of digestion are much more complex than was hitherto thought. The secretion of the intrinsic factor is but a case in point. It is now known that vitamin B_1 deficiency is the cause of lack of appetite and defective movements in the alimentary canal. It requires but little imagination to conceive that these effects must have some fundamental cause and that they could lead to a number of abnormal sequelæ, such as, defective absorption, stasis and toxæmia, to mention a few.

Recent knowledge about the requirements of proteins, carbohydrates and fats in a dietary.

The minimum amount of protein required for the dietary of man has been a matter of dispute for a long time. Originally found by Voit at 119 grms., it was afterwards raised by Atwater to 125 and subsequently lowered by Chittenden to 60. Sherman quotes it at about 44·4. It has now been recognized that the quest for a protein minimum is really an illusion, as it depends not on the quantity but on the kind of protein supplied. The work of Hopkins on the essential amino-acids in connection with nutrition has come into prominence in the present day. As has been pointed out by him, the food proteins which can be used with the greatest economy in the body are those which contain all the amino-acids in such relative proportions as will correspond most nearly with their proportion in the living tissues of the consumer. These are the proteins of so-called high biological value, constituting the 'first class proteins'. It has been observed that the average consumption of Cambridge under-graduates, those in training being excepted, is about 80 grms. of protein.

The problem of perfect diet.

There are many problems that await fuller investigation by physiologists and bio-chemists in future before the perfect diet can be proclaimed. A food in order to be effective, must be ingested by a body both physically and psychically sound. It is possible to be well-nourished on the simplest of dietaries. Who can say for certain what is the optimum protein diet or the optimum intake of fat? What about the food of the Eskimos, the human carnivores of the world, who live for long periods on purely animal food? Hindhede has emphasized the superiority of the high fat, low protein diet of the Danish farmers over the high protein, low fat diet of the neighbouring Finlanders. But is this applicable to all mankind? There has been much talk about the energy value of different foods expressed in calories. But, as Cathcart has said, are not these merely convenient units of measurement? How are we to explain the

deleterious effects of 'very high' cereal dietary and how are they corrected by 'protective' foods, such as milk and leafy vegetables? Do the cereals contain any toxins, which are neutralized by a proportional quantity of the protective food? What definite information is available as to the body needs of the different kinds of vitamins? A further question is the problem of hypervitaminosis, as also the actual part played by vitamins, and any difference which may arise from taking synthetic or natural vitamins.

Nearly 90 years ago, Chevers taught that the dietary of the Hindus with a very moderate quantity of animal food was the fittest for a tropical climate. Thus he wrote, 'It is certain, that the law-givers, who prescribed for the people of India a diet consisting mainly of vegetables and water, the lighter kinds of animal food, such as fish, pigeons and goat's flesh, being only occasionally introduced in moderate quantities, judged almost as physiologically as they could have done, had they studied at the feet of Liebig and Prout'. Similarly in a discussion on the dietary of man, the meatless diet of some of the finest soldiers of His Majesty's Indian Army who fought in the last great world war was highly extolled. This is an interesting subject for research in the quest of minimum animal protein required for human consumption and the future may show that it may be influenced by climatic conditions. Recent researches of Berg tend to show that apart from the nature of proteins, there are other factors which determine the minimum quantity of protein necessary to preserve nitrogenous equilibrium, such as, the particular protein the subject is accustomed to taking and the ratio of inorganic bases to inorganic acids available to or formed in the body of the subject.

This brings me to the question of animal *versus* vegetable protein. Investigators of the present-day hold that, in general, proteins of animal origin are superior to the vegetable proteins for the purposes of nutrition and that the testimony of human vegetarians is useless in determining the amount of animal protein requirement of man, because they were probably not vegetarians during the first part of their lives.

Are there first class fats? At present we know little about the nutritional value of different fats, but some work goes to show that certain fatty acids of the linoleinic series may be essential. It has been stated that the synthetic fat intarvin may be used by fasting persons of normal health without the development of acidosis. Do not these adumbrate the possibility of the existence of first class fats? Further work is also necessary to determine if there are essential carbohydrates.

Mineral constituents of diet.

In recent years there has been an advance in our knowledge of the importance of inorganic substances, especially minerals in our dietary. Many of these such as calcium and phosphorus

are required for structural purposes and their deficiency gives rise to structural diseases. There are others which are required to be present in minute quantities in our dietary and which are perhaps concerned with the stimulation of the active processes in the tissues. These are copper, manganese and perhaps yet other undiscovered elements. Their deficiency is regarded to be responsible for certain forms of anæmia, though very recently this view has been doubted by some observers. The possibility of the existence of undiscovered mineral deficiency in disease is for the future to reveal, and may I suggest that certain obscure diseases of India, such as, infantile biliary cirrhosis of children may be investigated from this point of view.

Complicated are the inter-relations of the vitamins, the hormones and the mineral constituents of the tissues in the prevention of certain diseases. For instance, biochemistry has shown that a supply of iron, copper, vitamin C and thyroxin are the essential factors in the formation of erythrocytes and hæmoglobin, in addition to an active bone marrow. Deficiency of any of these may give rise to certain types of anæmia. A generous supply of calcium and phosphorus together with a liberal supply of vitamin D is essential for the perfect development of the bones and teeth of the child.

Prolongation of life and rate of growth.

In recent times, studies in nutrition have been concerned chiefly with the maintenance of normal health and production of a rapid rate of growth. It has however been observed still more recently that prolongation of life associated with a retarded rate of growth has been noted in many divergent forms, such as, rats and brook trout and that animals kept on a restricted food intake for long periods outlived by a wide margin those that were allowed to eat full from the time of weaning. The inverse relationship of the rate of growth and the time of onset of senility is also apparent from other investigations. Evans has noted that animals injected chronically with preparations containing growth hormone of the hypophysis show evidence of premature senility. On the other hand, Lee and Schaffer have shown that administration of the pituitary growth hormone results in retention of juvenile chemical characteristics by the tissues. Other clues for the study of these problems are furnished by the facts that thymus extracts greatly increase the rate of growth and maturity while pineal extract seems to retard growth. Wetzel in his work on 'Motion of Growth' has shown that excessive rate of growth during infancy and childhood is associated with excess of wasteful heat production and that this may have grave consequences. It is apparent that some of the current tenets in the field of nutrition require reconsideration in an effort to determine the optimal rate of growth for each period in life.

It seems, however, that the preponderance of evidence indicates that the increased growth achieved by well-considered improvement in the diet is accompanied by general physiological betterment and definite improvement of the species. By intelligent improvement of nutrition of experimental albino-rats through successive generations there has been developed a new species of these animals.

Environment and improved nutrition.

In the present day, physiologists realize that a diet which appears to be adequate is not invariably the optimum diet. Better environment and improved nutrition will improve hereditary character and bring mankind to a higher level of physical development. Newer knowledge of nutrition may lead to the development of a larger stature, greater vigour, increased longevity and a higher level of cultural attainment (McLester).

Recent investigations into the Indian and Indo-Javanese dietary.

In a recent investigation into the diet of the Indo-Javanese in the Dutch Indies, it has been observed that on a diet which appeared hardly adequate from a European point of view the people of the country lived in a fairly good health, though their weight was of a somewhat low standard. The subject requires further investigation to determine what would constitute a proper dietary for the Javanese.

Coming to the Indian dietary, in recent times some interesting work has been done with the balanced diets for Indians by Tilak and his assistants. The dietary worked out by them is the inclusion with the staple food grains in common use by the people of India, of soya-beans, dried skimmed milk, rice polishings, fresh ground-nut cake and preparation of sprouted seeds. Such dietaries, if confirmed, may help in solving the problem facing large masses of people in India, i.e., how to obtain a reasonably good diet for 5 to 7 rupees a month. Aykroyd has found that diets which, in paper at least, adequately fulfil human requirements can be bought in Madras for about Rs. 4/- per month. 'Cheap balanced diets' of this nature must, of course, be subjected to the test of practice.

Perhaps millions of the people of India, especially among the poorer classes, suffer from various degrees of malnutrition which leads to lessened power of resistance to infection. McCarrison's work in this field is well-known. Sanitation and nutrition must go hand in hand in all countries especially in India, where so many diseases epidemic and endemic prevail.

Gastro-enterology.

Alimentary auto-intoxications, allergic conditions from imperfect metabolism, and auto-infections from the alimentary tract play an important part in medicine and the gastro-enterologists are claiming today that the science and practice of nutrition is becoming an independent and complete speciality, which is to be identified with theirs. Perhaps the Science of Nutrition, including the pro-

blems of the dietary of the people of a country, will, one day, form part of the department of preventive medicine of the State, as it has already begun to be in certain countries.

Recent dietary in diabetes.

In India where diabetes is common, the proper dietary of the disease is an important subject, and I shall very briefly refer to it. Since the epoch-making discovery of insulin in the treatment of diabetes, the pendulum is swinging from the fat diet of Newburgh and Marsh to 'high' and 'higher' carbohydrate diet of Sansum and others. Recently it has been observed that administration of carbohydrate stimulates the production of an unknown insulin-kinase, the insulin acting as a substrate in the metabolism of sugar (Himsworth). On the other hand large amounts of fat may inhibit the action of insulin. On this view a 'high' or 'higher' carbohydrate diet for diabetes aided by insulin finds a rational support and it is possible that, by the adoption of such a diet, the life of a diabetic may be more prolonged and death rate from diabetes more reduced than what has been achieved in the present day, in spite of the introduction of insulin.

Hyper-vitaminosis. Hyperhormonism. Anti-hormones.

In speaking of vitamins in connection with maintenance of nutrition, one cannot help making a brief reference to a condition discovered in recent times and known as hyper-vitaminosis. This consists of a series of toxic symptoms following the administration of excessive doses of certain vitamins such as A or D. It may be incidentally mentioned here that excessive production of the internal secretions of the ductless glands in the system, and administration of an excessive amount of the same may also give rise to toxic symptoms. The condition may be described as *hyper-hormonism.* Further it is possible that inhibitory principles may be produced as a response on the part of the body to the introduction of excessive amounts of various hormones, and that the clinician in his endeavour to correct a hypo-glandular state may actually add to the gravity of the condition by causing an overproduction of inhibitory principles, as a result of too persistent treatment with hormones (Collip). In diseases due to the deficiency of hormones, their artificial administration must therefore be intermittent and regulated according to the needs of the patient, just as they are normally manufactured and distributed according to the needs of the body in health. Whether inhibitory principles may be produced by excessive use of vitamins I cannot say.

Biological catalysts.

Before I leave this portion of my address, may I make a passing remark about the biological catalysts. The catalysts of a living cell are the enzymic structures which promote reactions within the cells and determine their direction. Perhaps in the main-

tenance of the normal reaction within the living cells, the vitamins, the hormones and the minute mineral constituents play an important part. The action of medicines and diseased products upon the permeability of the cells and upon the action of enzymes within them must be an important field for research and may be of great value in medicine for the study of chemotherapy and immunology.

PHYSIOLOGY.

No one can doubt that physiology has had a great influence upon the whole field of medicine in recent times.

Recent researches have thrown light on the mechanism of the fundamental reflex reaction for the protection of the animals and have shown how with the evolution of an anti-gravity mechanism and of extended movement, the brain stem has become evolved to take over this increased responsibility. Magnus has analysed the various nervous stimuli from the periphery which are concerned in this very delicately co-ordinated mechanism. The new data have completely revolutionized our conception of the nervous system, and signs and symptoms of disease which hitherto could not be properly understood have now become capable of analysis.

In more recent years Sherrington and his school have worked more exactly on the relation of the nervous system to responses produced when it is active. These fundamental studies will no doubt throw much light on the changes so often observed in disease. His researches have shown that the centripetal impulses do not pass straight through the spinal cord, but at certain stations in the cord they are transferred into an enduring excitatory state which may in turn set up fresh impulses yielding the reflex discharges.

Adrian's researches have also added greatly to our knowledge regarding the exact nature of the impulses which pass along nerves in different conditions. With a most admirable technique he has studied nerve impulse and its origin with highly profitable results. He has come to the conclusion that change of potential may be of fundamental importance in the activity of nerve cells. He has shown that damaged nerve fibres set up impulses at very high frequencies and these perhaps play a part in sensation of pain, though sometimes impulses in the smaller slowly conducting nerve fibres may also be concerned in the physical mechanism of pain. He has been able to observe the activity of a single nerve cell and has shown that human voluntary contractions are regulated in exactly the same way.

In Russia Pavlov and his school have elaborated the reflex reactions of the higher parts of the nervous system. Their results are capable of considerable application to many of the higher human activities.

A. V. Hill has studied the nerve impulses with exquisitely sensitive apparatus from the point of view of thermal phenomena accompanying it and it is becoming clear that the nerve impulse consists of a transmitted physico-chemical event, the whole cycle of event comprising activity and recovery in the nerve being supported by the energy derived from metabolic oxidative processes, associated with the cycle.

Further it is possible to conceive 'the nervous impulse as a succession of transformation of chemical into electrical energy, and conversely—these transformations being necessary by the structure of the fibres'.

Haldane and his pupils have continued their well-known work regarding the control of respiration. Carbon dioxide, formerly looked upon as a product of excretion, to be got rid of as soon as possible, has been shown by them to be an essential stimulus to respiration. This discovery has been of immense value in modern anæsthesia. Further it has been shown by Yandell Henderson of Yale University that carbon dioxide is also essential for the tone of the blood vessels. Dale and Evans have shown that carbon dioxide is essential for the activity of the vasomotor centre, just as it is responsible for the activity of the respiratory centres. Barcroft has shown the principles by which oxygen is transported by the blood. As a result of the work of Haldane, Barcroft and their co-workers, it is now possible to deal with respiratory distress and failure by more scientific methods than what was possible in former days.

Areas such as the cerebral and pulmonary vessels which were once thought to have a poor vasomotor supply have now been found to be much better supplied than had hitherto been imagined.

With regard to the heart, the earlier studies of cardiac disturbances by Mackenzie have played an important part in advancing our knowledge regarding the physiology of the heart, and the work of Starling and of Lewis has placed much of it on a strict experimental basis in more recent times. A new interpretation of the electro-cardiogram in disease has been recently evolved.

The discovery of the function of the carotid sinus by Hering and its study by Heymans have been of great value to physiology and to pharmacology as well. By the recognition of the activity of this sinus and its possible variations one can now explain many of the differences in response which hitherto have been a great drawback in experimental work. In the nerve connection of this sinus and the effect of pressure on it lies, according to some observers, the explanation of sudden death under gas anæsthesia.

One of the most important new facts discovered in recent years regarding digestion is the relationship of the proper functioning of the stomach to the production of blood, and the

subsequent application of this to the treatment of pernicious anæmia. This work had its origin in the physiological studies of Whipple on the normal regeneration of blood after hæmorrhage and administration of liver. Following the same line of research Minot and Murphy found that administration of fresh liver had a remarkable curative effect on pernicious anæmia. This led to the recent liver therapeutics for treatment of the disease.

The researches of Castle, however, connected the etiology of pernicious anæmia with defective gastric secretions. Recent experiments of Meulengracht have shown that pernicious anæmia in human beings may be due to atrophy and inactivity of that part of the stomach which comprises the pyloric-gland region and may be said to have localized the seat of origin of pernicious anæmia in human beings. Thus stomach preparations for the treatment of pernicious anæmia may with advantage be producible from the pyloric-gland region.

From a physiological point of view, these experiments give the pyloric glands a function. As we know, it has hitherto been difficult to ascribe such a function to the pyloric glands and the special pyloric-gland cells. Now it seems possible that the pyloric glands are the seat of special secretory function and secrete the substance Castle's 'intrinsic factor' that is essential to the blood and the nervous system.

These experiments open up the theoretical possibility that under certain circumstances pernicious anæmia may be due to an isolated atrophy or inactivity of the pyloric-gland organ without a simultaneous atrophy or inactivity of the fundus-gland organ, i.e., without simultaneous apepsia or achlor-hydria ('dissociated achylia') although judging from present clinical experience this possibility does not appear to be of much practical importance.

It has been shown by Loewi that the vagus nerve inhibits or checks the activity of the heart by the liberation of a chemical substance which directly influences the myocardium. This is a find of great importance, as there is increasing evidence that the activity of all nerves may take place through the agency of similar chemical substances. Cannon and co-workers believe that they are capable of appearing in two forms of combination, one producing only the augmentor and the other only the inhibitory effects of sympathetic nerves.

Extensive investigation as to the nature of the process by which nerve impulses influence the effectors has been carried out by Dale and it seems fairly established that all efferent messages eventually produce the desired effect by the liberation of either acetylcholine or of a substance like adrenalin. Dale distinguishes such nerve fibres as 'cholinergic' or 'adrenergic' according to the nature of the active substance liberated. The preganglionic fibres of the autonomic system, the motor nerves, and the post-ganglionic fibres of the parasympathetic belong to the 'cholinergic' category while the post-ganglionic

fibres of the sympathetic usually fall under the 'adrenergic' group. It has been pointed out by him that Langley and Anderson's evidence, long available, as to the kinds of peripheral efferent fibres which can replace one another in regeneration, can be expressed by the statement, that cholinergic fibres can replace cholinergic fibres, and that adrenergic fibres can replace adrenergic fibres, but that nerve fibres of different chemical functions cannot replace one another. This discovery has no doubt an important evidence on our new conceptions of the mode of action of 'neuromimetic' drugs.

Certain recent experimental studies tend to show that living tissues may be the seat of radiation able to produce effects at a distance, and that certain activities in one cell of a tissue may influence activities in a neighbouring cell and that chemical reaction may be accompanied by radiations, and events in one cell may thus influence other cells without material transmission.

The Endocrine glands. The glands of destiny. The Pituitary.

It has been held that the ductless glands are the 'glands of our destiny' and that 'these potent overlords of our bodies are dictators of our minds and personalities'. It may be possible that the future may reveal that genius, intelligence, beauty, character, morality, and other human characteristics are dependent upon diverse combinations of the secretions of these bodies, just as their deficiency or excess may give rise to disease.

Insulin has completely changed the prospect of the treatment of diabetes. The discovery that parathyroid extract mobilizes the calcium of the bones has revolutionized the treatment of diseases due to calcium derangement. Our knowledge of the interaction of endocrines has increased in recent times. I would just mention a remarkable fact that, as shown by Houssay and co-workers, there is no glycosuria when both the pituitary and the pancreas are removed, and further that the injection of extract of the anterior pituitary is followed by the appearance of glycosuria.

May I end this portion of my address by making a little more reference to the pituitary, which seems to have a multiplicity of functions. It may be regarded as the headquarters for the hormones or the chemical messengers which control most of the other endocrine glands and thereby probably almost every cell of the body. The chemistry of the pituitary is by no means closed and it may be that the most important discoveries in the pituitary chapter have yet to be written. It has been held that 'the integration of the endocrine system is based on the influence of the diencephalon upon the anterior pituitary, which through complex hormones acts on the other endocrine glands, stimulating or inhibiting the production of simpler hormones in them. These hormones are closely related chemically to other substances concerned in normal activities,

such as, the growth of the embryo, the growth of bone and calcium metabolism, as well as abnormal activities such as malignant growths.' Further, 'in general we can see a division of labour between nervous and hormonal events, and accordingly between the respective regulators, the central nervous system, and the anterior pituitary lobe. The central nervous system regulates principally the specific, acute functions; therefore it also influences those neurogenic endocrine organs, the adrenal medulla and the posterior pituitary lobe, the hormones of which cause acute changes. The regulator of the non-neurogenic hormonal system, the anterior pituitary lobe, regulates mainly the development and state, and partly also the secretion, of the remaining endocrine organs, the hormones of which bring about longer lasting changes of the conditions of many other organs' (Loewi).

In studying the developmental history of the remarkable endocrine gland, the pituitary, one finds that by the seventh week of embryonic life, as the base of the skull is being laid down between the roof of the pharynx and the floor of the forebrain, the stalk of the Rathke's pouch which forms the anterior and intermediate lobes of the pituitary body is drawn out and lies at the posterior border of the nasal septum. Usually some fragments of the pituitary stalk persist in the mucous membrane of the roof of the nasopharynx. Cases have been observed in which the whole pituitary body lies in the posterior part of the nasal septum. By the ninth week the stalk usually disappears, but occasionally a canal in the body of the sphenoid bone of the adult—the craniopharyngeal canal—marks the site of the embryonic stalk. Herring, very recently, has referred to the functions attributed by the ancients to the pituitary. We may make here a reference to the remarkable claims made by the ancient *Yogis* of India who practised what is known as *Khechari Mudra.* They elongated the tongue slowly by practice and manipulation aided by cutting its fraenum, if necessary, and carefully introduced it into the nasopharynx. The *Yogis* claimed to have developed remarkable powers of their body and mind in this way. Did they conceive that the tongue mechanically stimulated the secretion of the glandular structures in the nasopharynx (pituitary ?) which might be subsequently absorbed into the system, in the same way as adrenalin is absorbed when put under the tongue, and interact with the secretions of other endocrine glands ? Will some future investigator test the validity of the above claims ?

Tissue culture.

May I now say a very few words about tissue culture. 'Tissues cultivated *in vitro* show two types of growth, which are sometimes termed "somatic" and "uncontrolled" respectively.

'In somatic growth, which is usually seen best in cultures of early embryonic tissues, the explanted fragment behaves

to some extent as if it were still part of the body. It may increase in size by any or all of the three methods observed *in vivo*, viz., by the multiplication of cells, by the enlargement of cells and by the formation of intercellular material, and if removed from an embryo at an early stage of development often continues to differentiate during cultivation. For example, undifferentiated skeletogenous mesoderm will form cartilage and bone *in vitro*, explants of the undifferentiated retina give rise to nerve cells and rods and cones, and in cultures of the early mesonephros typical kidney tubules may develop.

'The second type of growth—uncontrolled growth, is perhaps more characteristic of tissues cultivated *in vitro*. Its main features are the progressive simplification of the original histological structure of the explant correlated with a diffuse outgrowth of the cells into the medium, and an increase in volume by cell multiplication only. Even in uncontrolled growth, however, cells never wholly depart from their original type, and epithelial and connective tissue cells remain distinguishable as such even after prolonged cultivation' (Fell and Willmer).

The Carrel strain of fibroblasts is the oldest set of cultures in existence, but there is evidence that certain types of epithelium and various forms of malignant tissue can also be made to live and multiply indefinitely *in vitro*. These results suggest that at least some types of vertebrate cells may be potentially immortal, just as certain types of protozoa or the flat worm may be kept indefinitely alive. It has been claimed by Wells and co-writers that 'if Dr. Strangeways had lived in the time of Julius Caesar and set a series of sub-cultures growing from a scrap of him, fragments of that eminent personage might, for all we know to the contrary, be living now'.

The recent invention in the Rockefeller Institute for Medical Research jointly by Carrel and Lindbergh, of a 'Life Chamber', a sort of artificial body of 'heart, lungs and bloodstream', has enabled scientists for the first time to keep the organs alive, functioning and even growing for a long period outside the body. The method of Carrel-Lindbergh consists of the transplantation of an organ or of any part of the body into a sterile chamber and its artificial feeding with a nutrient fluid through the arteries. In this way the thyroids and ovaries of animals have been artificially cultured, and made to grow. The perfusion fluid consists of protein hydrolytic products, hæmin, cysteine, insulin, thyroxin, glutathione, vitamins A and C, blood serum and other substances according to the necessities of the particular organ to be perfused. There is no doubt that tissue culture is likely to be of immense importance in the study of the human body and in the preventive and curative treatment of diseases.

I have briefly outlined how the sciences of biochemistry and physiology have been laid under contribution in the recent progress of medicine. There are, no doubt, various other facts

worthy of note in their application to medicine, but I have refrained from mentioning them for want of space and time.

It is pleasing to know that many of the investigators whose names I have just mentioned have been Nobel-laureates for researches in the subject group of physiology and medicine.

Genetics.

I hope it will not be regarded as transgression of the ambit of my subject if I pay a passing tribute to the recent activities in the field of genetics.

The account of Mendel's epoch-making experiments in his cloister garden, on the crossing of varieties of the common pea, somehow or other sank into oblivion for thirty-five years. But such was the potentiality of his work that, when rediscovered, it not only laid the foundation but also gave a new impetus to the study of the science of heredity. In recent times Mendel's theory of what were called by him *factors* (now known as *genes*) has received confirmation in the hands of Morgan and others. Their physical existence in the chromosomes has been proved and it is now known that the chromosomes are indeed the bearers of the hereditary units and that to their very reliable mechanism we owe the regular behaviour of the inheritance of characteristics from parents to children. Heredity is really a most remarkable phenomenon. The production, generation after generation, of offsprings identical in all but minor peculiarities with their parents is indeed one of the great mysteries of life, and it is by the orderly division of the chromosomes and their contained genes life can be maintained. It is becoming more and more established that ' the general laws laid down by Mendel have as wide a validity for genetics as have Dalton's for chemistry '.

The practical outcome of the application of the principles of genetics as demonstrated by the magnificent work in research laboratories such as those at Cambridge, Edinburgh, Aberystwyth, and Aberdeen, has been of immense value in improving crops and live-stock. The boundless possibilities in heredity revealed by the science of genetics have placed great power in the hands of breeders of plants and animals and they can now tell with approximate accuracy what to expect from matings. This knowledge has revolutionized breeding in all directions, and resulted in the production of bigger and better plants and animals used for food, clothing or pleasure. In the course of time man may be able to replace the natural selection of more fertile mediocrity and the artificial sterility of high-grade parents by human selection and the artificial fertility of high-grade parents. Sooner or later the frequency of the latter would increase in geometrical progression and control and guide the qualities of mankind in any way it desires for the good of man. The future

trend of creative evolution, including man's own destiny, depends on his response to the new knowledge and on his intelligent application of genetical discoveries, in the near as well as distant future (Hurst). Genetics aided by better environments may also be able to prevent the transmission of hereditary weakness and hereditary diseases, some of which are sex-linked. In this way it may lead to the production of better type of men, free from diseases of the mind and body that are propagated from father or mother to their children and thus the difficult task of medicine for averting or curing hereditary diseases or diathesis will be reduced to a minimum.

CHEMISTRY.

It has been recently remarked by Lord Moynihan that perhaps in the relation of physics and chemistry to medicine, we stand on the very threshold. Let us see what advances have been made at this threshold in recent times.

I begin with the recent contributions in therapeutics due to the application of chemistry. If I were to attempt to enumerate the various compounds that are brought every day to the notice of the medical profession in recent times, as hypnotics, anæsthetics, analgesics, antipyretics, antiseptics, or for other therapeutic purposes, then their number will be legion and my task may be impossible. I shall therefore refer briefly to a very few principal therapeutic chemicals of recent times.

How complicated is the mechanism of chemotherapy is shown by the fact that a slight alteration in the constitution of a compound may bring about a complete change in its physiological properties. This is well-exemplified in the preparation of the various amino-quinoline derivatives for antimalarial purposes. A slight change in the constitution of these compounds leads to a complete disappearance of these properties. 6-amino-quinoline and 8-amino-quinoline have no action on paramoecia in strength of 1 : 4000. The introduction of OH into 8-amino-quinoline and quinoline-8-glycine-amide raises their toxic action on paramoecia to a remarkable degree and the methylation of 6-oxy-8-amino-quinoline by replacement of H of OH by CH_3 reduces its action on paramoecia to nil (Brahmachari and co-workers). Diethylmonosulphone is without hypnotic action, while both dimethylsulphonediethylmethane and the isomeric diethyl sulphonedimethylmethane (sulphonal) a e strongly hypnotic.

Anæsthetics and Hypnotics.

Amongst the more interesting synthetic drugs introduced in recent times are those recommended for producing anæsthesia, when given by injection, preliminary to and partly replacing the use of volatile anæsthetics.

Though it may be held that inhalation anæsthesia seems to hold its own which is, to a great extent, due to the development of the gas and oxygen method, yet attempts are being made to introduce, in recent times, other synthetic compounds which may be used for anæsthesia.

The new basal anæsthetics include tribromoethyl alcohol (avertin), urethanes and some of the newer substituted barbituric acids. Most of them are sodium compounds, such as soneryl sodium, amytal sodium, evipan sodium, pernocton, and nembutal. Among the general anæsthetics that have been introduced in recent times may be mentioned evipan sodium, and cyclopropane and di-vinyl ether.

To one coming from Calcutta, the history of anæsthetics has a peculiar interest, because Waldie, who was one of the pioneers of chemical research in India and who lived in Calcutta, was associated with the discovery of the anæsthetic properties of chloroform in 1844. To his memory there is a tablet in the rooms of the Asiatic Society of Bengal. To all of you, the same must also be of great interest because the first chloroform commission was held in India.

There is no doubt that general anæsthetics have been conducive to the advance of all branches of medicine. 'The medical sciences, physiology, pharmacology, pathology and bacteriology would have remained inaccurate and incomplete hand-maidens of medicine, had it not been made possible by the aid of anæsthesia to critically examine, corroborate or disprove the claims, hypotheses and tenets of workers of all types.' (Stander.)

Synthetic chemistry has produced numerous local anæsthetics better than cocaine. A new era has been opened to the operating surgeon. His visitations on the most delicate parts are performed, not only without agonizing screams he has been accustomed to hear, but sometimes with a state of perfect insensibility, and occasionally even with the expression of pleasure on the part of the patient. Who could have imagined that drawing the knife over the delicate skin of the face might produce a sensation of unmixed delight! That the turning and twisting of instruments in the most sensitive bladder might be accompanied by a beautiful dream! (Warren.)

We are steadily approaching the solution of a perfect analgesia for labour.

In recent times, much work has been done in the quest of a suitable hypnotic. The demand for a good hypnotic has grown more and more intense of late, because due to the stress and strain of modern life, many ask for an ideal draught or a tablet or a pill which would quickly put them in possession of 'tired nature's sweet restorer, balmy sleep'. From the hypnotics of olden times to recent ones, the chemist has travelled

a long way, and he is still moving further and further in the search for better hypnotics.

The chief advances in our knowledge of hypnotic drugs in recent times have been (1) the discovery of many new derivatives of the barbituric acid series; (2) the introduction of a number of drugs other than alkaloids for purposes of basal anæsthesia.

The barbituric acid derivatives are perhaps the most commonly used hypnotics at the present day. Other recent hypnotics not derived from barbituric acid include avertin.

An ideal hypnotic should be free from any toxic effects, should be quickly excreted and should give a quiet natural sleep of normal duration in a short time. Such a hypnotic has yet to come. Further the same hypnotic is not suitable for all types of cases and sometimes methods other than hypnotics are suitable for individual persons for relief of sleeplessness.

May I now refer to the hypnotic properties of the extracts from the root of Rauwolfia Serpentina. As early as March 1912 the speaker read a note on its alkaloidal principles and therapeutic properties in a meeting of the Asiatic Society of Bengal. The extracts have marked hypnotic properties and are specially indicated in certain forms of insanity. Since the above paper was read, much work has been done on the chemistry of the drug and many alkaloids have been extracted from the roots. Its hypnotic properties may be due to these alkaloids.

I now pass on to certain aspects of chemistry in its application to a few protozoal diseases as revealed by recent researches.

Organic arsenicals.

The best known of trivalent organic arsenicals is salvarsan, for which the non-proprietary name arsphenamine is in common use in the British Empire and the United States. The drug is now generally used in the form of one of its two principal derivatives. The first of these is neo-arsphenamine, the second is sulph-arsphenamine. The first pentavalent organic arsenical used in the treatment of trypanosomiasis was atoxyl. An important derivative of atoxyl is tryparsamide. It has been found very successful in the treatment of trypanosomiasis. Other new therapeutic organic arsenicals include stovarsol, etharsanol, proparsanol and carbarsone.

Symmetrical ureas.

The first and best known of the symmetrical urea group of trypanocidal drugs is Bayer 205 or germanin. In 1924 Fourneau and collaborators described the production of a symmetrical urea, which is now obtainable in France under the name Fourneau 309 (moranyl) and is identical with Bayer 205.

Quinoline and acridine anti-malarial derivatives.

Schulemann and his colleagues succeeded in increasing the antimalarial properties of methylene blue by replacing its short side chains by a longer chain. Investigation subsequently conducted with the quinoline nucleus led to the discovery of beprochin afterwards named plasmochine or plasmoquine. Similar experiments were made later with other heterocyclic nuclei including acridine and this led finally to the discovery of atebrin. These compounds are of great therapeutic value in certain forms of malaria. In Calcutta a number of amino-quinoline compounds are being synthesized under the speaker's direction and their antimalarial properties tested. Some of them have already been reported to have a marked action upon paramecia.

Leishmanocidal organic antimonials.

One of the most terrible of tropical diseases, so far as certain parts of India are concerned, is kala-azar. Antimony, which was once banned to such an extent that the graduates in medicine of the University of Heidelberg had to swear never to use it, has now been found to be its specific. By the introduction of organic antimonials in its treatment, the mortality of this disease has been reduced from 99% to about 1 or 2% in uncomplicated cases. The terrible nature of this disease in its epidemic form when it ravaged Bengal in the Seventies was well described by a contemporary writer as follows :—'The devastation of the epidemic has a very sad tale to tell. Countries that once smiled with peace, health and prosperity, have been turned into hot-beds of disease, misery, and death. Villages that once rang with the cheerful, merry tone of healthful infants, now resound with loud wailings and lamentations. Huts, which offered too little space for their occupants are left without a tenant. The skulls of human beings now strew the fields at every few yard's distance. The fell disease has mocked every human effort, and absorbed in its powerful grasp, day by day and inch by inch, every blessed spot which once used to be prized for its salubrity' (Roy).

It was doubtless a very great advance in the treatment of the disease from massive doses of quinine to tartar emetic which was the first antimony compound introduced by Rogers into India for the treatment of kala-azar. Soon after the introduction of the latter, the speaker conceived the idea of using sodium antimonyl tartrate (Plimmer's salt) and tartar emetic was soon replaced by this compound.

The next step in the treatment of the disease was the introduction by the speaker of the intravenous administration of metallic antimony in a state of fine subdivision, which was attended with remarkable benefit. It was observed that when injected intravenously the particles of antimony are picked up by the same cells in the spleen as those that

harbour the parasites of kala-azar, that the two contending agents thus come in closest contact with each other in these tissue cells, and that the fight ends most remarkably in the complete destruction of the parasites in the speediest way.

The next further advance in the treatment of kala-azar was the introduction of certain organic compounds of antimony and the use of these compounds in kala-azar infection has been the subject of the speaker's research for many years, and in 1920 some of them were prepared for the first time in India in the Calcutta Campbell Hospital.

Early in 1921, the speaker discovered an urea antimony compound for the treatment of kala-azar. Its introduction and his other researches on antimonial compounds opened up a new vista in the treatment of the disease in India by means of therapeutic organic antimonials, just as the discovery of salvarsan led to the introduction of organic arsenicals in the treatment of spirochætal diseases. This urea compound was named 'urea stibamine'.

I shall not detain you here with the romance of urea stibamine, however interesting it may be. But I recall with joy the memorable night in the Calcutta Campbell Hospital at Sealdah when after a very hard day's work at about 10 P.M. in a little room with a smoky dimly burning kerosine lamp, the speaker found that the experiments in the preparation of this compound were up to his expectations. The room still remains, but the signs of a laboratory in it have completely disappeared.

The first series of cases treated with this compound were published early in 1922. Soon after this, most remarkable results were obtained with it by Shortt in Shillong to whom the compound was sent for trial. The value of this compound was quickly recognized. It was introduced, soon after a preliminary experimental trial, by the Government of Assam for the treatment and prophylaxis of kala-azar.

Today urea stibamine stands pre-eminent in the treatment of kala-azar in India and as a powerful prophylactic against the disease, and it is a matter of supreme satisfaction that this treatment has been the means of saving the lives of a vast population of suffering humanity.

The following remarks from the Annual Public Health Report of the Province of Assam for the year 1933 dated 23rd July, 1934, are worth quoting: 'It has to be borne in mind that, when no specific remedy was known for this disease, that 98 persons at least out of every 100 were doomed to certain death within a comparatively short space of time. Since 1923, when reliable figures for the disease first became available to the end of the year under report, no less than 328,591 persons have been brought under treatment. It is no exaggeration to say that approximately 3·25 lacs of valuable lives have been saved to the Province'.

Further advances have still to be made in the treatment of infections with leishmania donovani, as there are antimony-resistant cases, though fortunately few, and the treatment of that ugly skin infection which was first described by the speaker as a post-kala-azar condition and known as dermal leishmanoid is frequently unsatisfactory. Cases of this condition may be a menace to a community, as a possible reservoir of the parasite of kala-azar.

Chemical structure and physiological properties.

Dealing with the relationship between chemical structure and physiological properties one meets with a remarkable series of compounds in recent times having a common nucleus but possessing varied physiological properties. I mean the compounds having the condensed benzene ring system or phenanthrene, as well as, the reduced phenanthrene plus a fourth five-membered carbon ring or cholane. The cholane nucleus is found in bile acids, cholesterol and other sterols.

A structure of the cholane type is also found in the sex hormones which are responsible for the secondary sex characters of animals. These hormones are œstrone, luteosterone and the male testicular hormone or androsterone. They have close structural relationships with each other and with bile acids and cholesterol which probably contain their biological precursors.

The male sex hormone or androsterone has been artificially prepared. Friedmann has pointed out that the aromatic ring, corresponding to ring A of œstrin is not necessary for the development of the œstrogenetic effect as the benzene nucleus can be replaced by the furane ring, fural-pyruvic acid being even more active than benzal-pyruvic acid. Recent experiments suggest the possibility of getting œstrogenetic activity in ring-free compounds by arranging the carbon atoms 13, 14, 8, 9 of œstrin in a suitable way.

Synthetic hydrocarbons containing the phenanthrene nucleus, such as dibenzanthracene, are found to possess carcinogenic properties. The cancer-producing action of certain tars is due to the presence of a hydrocarbon allied to dibenzanthracene. It has been synthesized and the powerful carcinogenic action of the pure substance has been confirmed. It is, perhaps, the most potent carcinogenic substance so far discovered.

The aglucones, that is, the non-sugar parts of digitoxin, strophanthin and several other closely related substances are allied to the sterols as they embody structures of four carbon rings. Bufotoxin has a constitution closely allied to those of the cardiac aglucones and possesses a characteristic action on the heart similar to that of digitalis preparations. The phenanthrene nucleus is present in some of the most powerful alkaloids. such as morphine and codeine of the opium group, and the corydalis alkaloids and in colchicine.

All hormones of the secondary types contain benzene rings. In some cases the ring is a simple one as in thyroxin, pituitrin and adrenalin. In others it is a complicated one, the condensed phenanthrene ring. The Needhams and Waddington have observed the most remarkable phenomena that the chemical organizer or, as they call it, the evocator which determines certain developments of the embryo, belongs to the same group.

Recent knowledge about the chemistry of vitamins and hormones.

X-ray work on vitamin B_1, B_4 and C has been carried out in recent times and the structural formula of C as *l*-ascorbic acid has been established by a close collaboration of crystal analysis with the ordinary chemical methods.

The structure of carotene and vitamin A has also been established by X-ray analysis, as consisting of *cis*-polyene chain which is presumably the chain of polymerized rubber.

Vitamin B_1 possesses two ring systems, one a glyoxaline or pyrimidine and the other a pyrrole containing a substituted sulphur. It is not allied to flavins. Vitamin B_1 possesses anti-beriberi properties. The crystalline specimens of Jansen and Donath are, according to most recent observations, the pure vitamin itself with the admixture only of a small and variable amount of inactivated vitamin.

Vitamin B_2 is a complex, containing flavin and another factor, the absence of the latter and not of flavin being considered responsible for the symptoms of pellagra in rats. The flavin factor exerts a growth-promoting action. A substance identical with lacto-flavin of milk which is allied to vitamin B_2 has been isolated and synthesized. Examining the oxidation-reduction properties of flavin-cleavage products, Kuhn and Moruzzi were able to sum up the relationship of the flavin group by saying that the parent substance was a reductant; that combined with a ring system which contains a substituted amino group it produced a colour; that the addition of a carbohydrate side chain yielded a vitamin; and that the further addition of a protein group resulted in an enzyme (the yellow respiration ferment of Warburg).

Vitamin C is closely related to simpler carbohydrates and sugars. It is a keto-hexonic lactone.

Vitamin D can be artificially prepared from irradiation by ultra-violet rays. It has been isolated from irradiated ergosterol in a crystalline and apparently pure form, the crystalline compound being known as calciferol. The production of vitamin D by the irradiation of the sterols of the skin by ultra-violet rays of the sun is a most interesting chapter in the history of medicine, reconciling, as it does, the dispute whether rickets is due to a deficiency in the diet or want of proper sunlight.

Rapid progress is being made today in the isolation of hormones in a chemically pure condition. The hormone thyroxine, the active principle of thyroid gland, the iodine-containing amino-

acid has been synthesized by Harington and his collaborator Barger from tyrosine from which it is probably formed in the animal body. Kendall of the Mayo Research Institute has succeeded in preparing what appears to be the hormone of the suprarenal cortex, which may be beneficial in the treatment of Addison's disease. Ephedrine and pseudo-ephedrine are alkaloids isolated from species of ephedra and are chemically allied to adrenalin. Physiologically ephedrine and adrenalin behave similarly in many respects. Epinine, a synthetic compound, possesses, in a marked degree, the pharmacological action of adrenalin.

The specific Carbohydrates.

The discovery of type specific carbohydrates is among the most remarkable triumphs of chemistry in recent times. It has been observed that a derivative of gum arabic possesses properties resembling those of the specific polysaccharides of one of the types of pneumococcus serum. The value of polysaccharides possessing immunological functions, and the knowledge of their composition, properties and structure must be of great value in medicine. The polysaccharides of the cholera bacilli and of B. dysenteriæ (Shiga) have been investigated.

Isotopes and heavy water in relation to life.

Vernadsky has put forward a hypothesis that the living organisms possess a selective power between isotopes of an element. Among the plants, Loring and Druce have shown that in the potassium of potatoes isotope of atomic weight 41 predominates while in ordinary potassium the chief isotope is of atomic weight 39. In the case of man the future may reveal that isotopes of elements play an important part in the maintenance of health and that they may vary in disease.

Barnes has suggested that the polymerized molecules of water are of primary importance in physiological processes. The discovery of the hydrogen isotope (deuterium) of mass 2 and the isolation of quantities of 'heavy water', containing this isotope have opened a new field in the physiology of water. Gortner considers that the water in the Medusa is as much 'alive' as are the proteins, the fats, the lipides, or the carbohydrates. The water relations and different molecular forms of water in the living organism lie at the foundation of problems concerning both health and disease. It has been held by him and others that in lyophilic hydrosols and hydrogels the water may exist in two states, i.e., in the state of free water which is characteristic of water in bulk and in the state of bound water which is characteristic of the lyophilic system, and that the equilibrium between free and bound water is undoubtedly of major importance in vital phenomena. Two hypotheses have been presented as to the possible nature of bound water: (1) an oriented adsorption of the water dipoles at the interface, and (2) an oriented adsorption of hydrogen and hydroxyl ions. The effect of the substitution of the deuterium

form of hydrogen in place of ordinary hydrogen and of the isotopes of other elements into organic molecules may have in the future an important application in biochemistry and medicine.

I have referred only to a very few achievements in medicine due to the application of chemistry in recent times. The advance has been so very great that even in snake venom has been found a therapeutic application for the relief of the terrible pain of inoperable cancer or as a systematic hæmostatic in uncontrollable hæmorrhage. The sex hormones are having therapeutic applications, and the pregnant mare's urine has been found useful in pituitary cachexia with disturbance of circulatory regulation and on the metabolism of carbohydrate and fat. Ovarian extracts have been used in the treatment of hæmophilia.

The relation between chemical constitution of compounds and their varied physiological and therapeutic properties, though at present consisting mostly of jumble of empirical facts may one day lead to generalization of vast importance. Therapeutics is moving today from merely qualitative to quantitative foundations. Some of you may live to see that remarkable results may be attained by chemistry in the treatment of diseases like tuberculosis or cancer for which chemical therapeutics has at present day only a limited application in gold or selenium and lead respectively. It may be mentioned in passing the interesting results obtained in Berlin by Fischer on cancerous rats. By keeping these animals in pure oxygen, under a pressure of 1·5 kg. per sq. cm. for 24 hours, he observed that the tumour exploded literally outside of the body, tearing the skin, and was finally eliminated as sloughing tissue. Crystalline insulin free from impurities is now available. Mandelic acid, phenylhydroxy-acetic acid and its sodium salt are very recently coming into use in the treatment of B. coli infection of the urinary tract, the principle of treatment being based on the fact that a ketogenic diet leads to the production of β-hydroxybutyric acid which is the effective agent in the urine of patients treated with a ketogenic diet and which is allied to mandelic acid. Newer treatments of epilepsy, of myasthenia gravis and of agranulocytic angina are coming in the field due to the triumphs of chemistry. You may see the synthesis of other and newer vitamins and internal secretions as well as extracts from different organs of the body synthesized or isolated in a pure state and used in medicine for the treatment of disease. We look forward to the day when endocrine preparations will be available for oral administration and the dread of the needle averted.

Physics.

I now pass on to the contribution of physics to medical science. Its application is partly for the purpose of diagnosis

of diseases and partly for their treatment. Further, physics is slowly evolving new conception of living matter by X-ray analysis, by improved methods of microscopy and by the advancing knowledge of the constitution of matter.

It is not my intention to give here an account of the various apparatus that physics has made available for the diagnosis and treatment of disease as such an attempt will be merely cataloguing. I shall only refer here to some of them that have been of striking value in medicine or that may prove useful in the study of the structure of organic matter.

The Electro-cardiograph.

The Electro-cardiograph is a valuable apparatus for studying certain diseases of the heart. A portable apparatus which can be taken to the patient's house and which is constructed on the principle of the string galvanometer is now available. Another portable Electro-cardiograph based on the principle of the valve-amplifier is also available. By means of a special Electro-cardiograph outfit, simultaneous records of a heart may be obtained in the wards of a hospital for purposes of research showing (1) heart sounds, (2) electro-cardiogram, and (3) carotid pulse by means of Hill's wire sphygmograph. An apparatus consisting of a Stethograph combined with an Electro-cardiograph is now available. The combined Electro-cardiograph Stethograph may prove a valuable aid in cardiology.

The Electro-cardiograph has shown that tracings taken of patients dying of various maladies can demonstrate that for some time after clinical death, some cardiac activity could be registered, the duration varying from six to twenty minutes. These observations show that in cases in which there is cardiac stand-still during anæsthesia or in the new born, resuscitation may be effected by timely cardiac injection or needle puncture. There may be other conditions that may be discovered in future in which the same may be possible.

It may just be mentioned here that a convenient new method of assay of vitamin B_1, based on electrocardiographic measurements, has been recently described.

An Electro-encephalograph of the future.

One of the most recent advances in biophysics is the discovery of some electrical phenomena in the human brain, which were originally studied by Berger and subsequently by Adrian and Matthews, the latter observers using the Matthews' Oscillograph constructed on the principle of a valve amplifier. The electrical changes consist of a rhythmic oscillation of potential with a frequency of about 10 per second appearing when the person experimented upon lies quietly with eyes closed and disappearing when his attention is fully occupied. Non-visual activities which demand the entire attention, e.g., mental arithmetic, as well as sensory stimuli demanding the same, abolish the waves.

Berger considers that this 'Berger rhythm' represents the normal activity of every part of the cortex of the brain, while the experiments of Adrian and Matthews point to the conclusion that they arise from the activity of cortical cells in some parts of the optical lobe connected with vision.

I consider that future researches in this line may be as important in studying, as pointed out by Hopkins, the functions of the brain as the electrical changes in the heart are in studying cardiac diseases. An Electro-encephalograph may then be a valuable apparatus in medicine and may be useful for the study of the diseases of the central nervous system or of the mind, such as, anxiety neurosis or psychosis as the Electro-cardiograph has been in studying the diseases of the heart. Further work in this direction in the hands of Adrian and his co-workers is awaited with keen interest.

Ultra-violet ultra-microscopy.

One of the latest developments in microscopy is the use of ultra-violet light with dark ground illumination. Barnard's technique and apparatus have made photography with ultra-violet light as certain and reliable as ordinary photomicrography. His microscope has already revealed the structure of some of the viruses and inclusion bodies. We are beginning to learn that there is no clear line of demarcation between the ultra-microscopic viruses and the visible bacteria. I hope that further advances in ultra-microscopy with shorter waves, aided with improved methods of fine adjustment and electrical equipment for producing the spark source, will in future reveal the nature of the bacteriophage, and that of the smaller viruses which is not possible at the present day without the aid of biological tests. Differential centrifugalization, graded ultra-filtration, the recently developed methods of electron diffraction and micro-dissection may be helpful in this direction.

Thanks to the recent advances in the Ultra-microscope the nature of the filtrable viruses as a biological problem has assumed a new aspect in recent days. The view that viruses are small micro-organisms similar to ordinary bacteria is being daily confirmed. There is reason to believe that the size of the smallest virus which behaves like living organisms approaches that of the largest organic molecule. Until recently little evidence was available to suggest the existence of what may be termed saprophytic viruses except that of Rivers and Tillett who demonstrated in 1923 the presence in the testicles of rabbits of a virus that is not normally pathogenic. Barnard has however demonstrated by means of refined examination of the deposits, which sometimes occur in medium containing horse or rabbit serum, the presence of minute bodies, which in size, shape as well as general optical properties are in no way different from undoubted pathogenic viruses. These bodies increase in number and are

seen to be in process of fission. They have been cultivated to the fourth sub-culture. This demonstrates the existence of viruses which are saprophytic in habit, and tends more and more to lend support to the theory that viruses are living organisms. The recent announcement made by Stanley of the Rockefeller Institute however complicates our conception of viruses. He has reported the separation, from the juice of Turkish tobacco plants infected with the mosaic disease, of a crystalline protein that has the properties similar to tobacco-mosaic virus. It is too early to speculate on the eventual significance of this fundamental contribution, with regard to its relation to virus diseases in animals or to other virus infections of plants.

There is experimental evidence in recent times that the casual agent of acute rheumatism is probably a virus.

It is not my intention to continue further remarks on ultra-violet ultra-microscopy but I can foresee that aided by X-ray analysis it will reveal in future more and more new facts about the viruses and the bacteriophage than what is known in the present day and that the doubt very recently expressed by some observers whether the viruses will ever be seen will cease. The association of viruses with the specific micro-organisms in bacterial diseases may in future be found to be more common than is imagined at the present day.

Infra-red photography.

Photomicrography with infra-red light makes it possible to investigate, with transmitted light, many objects which are black or very dark brown in colour, and which consequently absorb very strongly both white light and for the most part also ultra-violet light. The infra-red rays enable one to photograph the veins of the skin or the diseased condition of its deeper layers or of the iris under an opaque cornea.

The Micropolychromar—Optical staining of colourless objects.

In studying under the microscope colourless objects, medical, zoological or botanical, we meet with difficulties, because as a rule they exhibit little optical contrast and are barely visible. The usual procedure of chemically staining such objects is tedious and kills them unless they are stained with vital stains. The Micropolychromar opens up a new avenue for scientific investigation of such colourless objects. It provides a means of 'staining' them not chemically but optically. This optical staining has the effect of showing up the object brightly illuminated in one colour on a differently coloured background. The objects are not merely differentiated from the background by virtue of their relative brightness but even when the background is as bright as the object, the object and background appear in contrasting colours. By means of this optical contrast staining, the fine structures are revealed with remarkable distinctness, the apparatus combining in one image the advantages of both dark field and bright field illuminations.

The value of such an apparatus in studying the structures of living cells and tissues particularly chromosome structure may be great.

Ultropak.

One of the recent advances in microscopy is due, to a great extent, to changes which have taken place in methods of producing the appropriate type of illumination. Of special importance is the arrangement for polarized light recently evolved for the Ultropak. This arrangement eliminates completely the glare and haze which arises from direct reflection, so that the inner structure of the object may be observed in every detail and with a remarkable degree of distinctness, the image of the object being formed only from diffused depolarized light reflected from its structure. It is a useful aid for the up-to-date worker engaged in microscopical research in general biology, zoology, parasitology and in experimental medicine, in which the observation of living organisms under high microscopic magnification is involved.

X-ray crystal analysis. Its aid to Organic and Bio-chemistry.

But evidently the microscope has its limitations. Sir William Bragg's application of X-rays has led to the discovery of the proper structure of matter which is beyond the limits of the microscope. Until quite recently, the majority of the tissues, such as the hair and skin, were believed to be non-crystalline, but recent investigations by means of X-rays and crystal physics have shown this belief to be incorrect and it has even been held that entirely non-crystalline materials are very difficult if not impossible to find. Minute regularities which are beyond the range of the microscope can now be detected by means of the X-rays.

Speaking of the crystal structures of the solid state, as revealed by X-rays, Sir William Bragg has stated that all the investigations of the solid bodies of every form aim at finding out the connection between their properties on the one hand and composition and architecture on the other. While some of these properties are directly dependent on the atoms of the unit cell in the crystal, there are others which depend on atomic relations which are not fully developed within the cell. The action of the atomic forces in groups of hundreds or thousands or tens of thousands of atoms must be considered before we can understand these other properties of the solid state. It is within a region of dimensions covering groups like these and somewhere in the scale of sizes there perhaps enters, as Sir William Bragg says, the breath of life to control these atomic compositions which enter into living organism. It has been stated that 'in structures produced by organisms, forces are active in their formation which are not present in solutions when ordinary crystals are deposited. The presence of these additional forces in living protoplasm prevents a clean-cut regularity in arrangement of the molecules; that is, it

introduces irregular arrangement of the molecules, or a degree of amorphousness. If this is the case, then the determination of the space group for a given organized substance will have little value' (Sponsler). But it is possible that further improvements in X-ray analysis may prove one day useful in considering the activities which occur in the protoplasmic matrix of organisms, and of structures which are produced through vital process. They may enable us to look into the mysterious protein molecule without destroying it and to discover whether diminution of the above-mentioned forces in any tissue in disease or their cessation in death may be accompanied by a change of the amorphousness of the aggregates of the molecules to some more or less characteristic crystallite or crystalline state.

X-ray methods of analysis may be applied one day in the study of the cancer cell and it is hoped that its application may increase our knowledge of cell construction and cell growth, which helped by our future knowledge of the colloidal state in living cells may one day strengthen our powers in combating the dreadful scourge of malignant disease. The changes that take place in the tissues in cancer and other pathogenic conditions have been studied by this method by Clark and co-workers.

The animal fibres are built of stringy protein molecules, which are made of strings of groups of atoms. The length of these groups which are marked by joints at regular distances is always the same but their breadth varies and therefore a protein chain is more irregular than a cellulose chain. The protein chains can be made up in many different ways. The difference between species of animals may be due to changes in the order of the groups in protein chains contained in their body. If due to an accident or disease, the order of the groups in a protein chain in the dividing chromosomes of a fertilized ovum was upset, the basic pattern for part of the tissues of the embryo would be changed, and as the tissues would subsequently grow according to the new pattern, the final structure would have a new pattern and different properties. The shuffling of the order of the unit groups of protein chains may be a fundamental agency in the process of evolution, normal or abnormal. It is difficult to determine the order of the unit groups in a protein chain by the methods of organic chemistry. But X-ray analysis may make the problem easier in future. A comparative study of the orders of these groups in the proteins of animals is now becoming possible and may one day enable one to investigate the internal structure of the organs more minutely than what is possible at the present day. There is no doubt that X-ray analysis has opened up a new way for the study of living matter.

Electron diffraction gives information similar to that given by X-rays but with the important difference that a much smaller

thickness of material is effective in producing the diffraction pattern. Layers with a thickness of about 10^{-6} cm. containing ten molecular layers or thereabouts have been used and the effective thickness can be made smaller still by using slow-speed electrons. Another modern branch of physics is being developed which may be of practical application in crystal physics, namely the technique of molecular rays. These have up to the present been used chiefly for studying the properties of atoms or molecules of substances which can be obtained in the vaporised state, such as the metals, the common gases, a few inorganic salts, and some organic liquids. Such a technique or that of electron diffraction may one day find application in medical as well as in textile research. The processes of adsorption of drugs and dyes in the treatment of disease as also of antibodies as well as many other facts in immunity might in future be studied by these techniques.

Spectrograph.

In recent years a new field has been opened up by the Spectrograph in the domain of chemical analysis, both qualitative and quantitative. It has now become possible to apply spectrum analysis to biological problems, among which are to be counted all the questions arising in theoretical and practical medicine regarding the metabolism of the heavy metals and its significance for the organism, whether healthy or diseased or the treatment of disease by the administration of heavy metals (Gerlach and Gerlach).

Until recently the only metallic elements considered as playing an important part in animal and vegetable life were sodium, calcium, phosphorus and iron and, to a less degree, potassium and magnesium and to these may be added silicon. The powerful influence sometimes exerted on life by very small quantities of elements, such as, copper, arsenic, mercury, iodine and boron, etc., as revealed by recent knowledge has led to an increasing need for improved rapid and accurate methods of analysis for detecting and estimating minute quantities of elements. Results obtained by the flame method of spectrographic analysis are applicable for this purpose.

As an example of the application of the Spectrograph to medicine, 0·1 c.c. of blood may be taken from a patient suffering from severe anæmia every 10 or 12 days to study the effect of treatment. The blood is rolled up in small places of ashless filter paper and spectrographed on a plate and thereby changes in the various constituents of the blood, such as potassium, rubidium, magnesium, calcium, iron and copper may be readily followed.

It has been shown by this method that human hair and finger nails contain minute quantities of copper and silver, varying in quantities with the age of the people. By its means the routine determination of the vitamins may be studied.

The study of absorption spectrum bands given by the different vitamins has helped in the work for the determination of the chemical nature, the concentration and assay of vitamins. Similar methods of hæmoglobinometry are now available. Spectrum analysis has become of great importance in pathological as well as forensic medicine for detecting traces of metals in human organs. It has been recently employed for studying the nature and the constitution of the amino-acids of the protein molecule as well as for their quantitative analysis.

Ultracentrifuge.

Studies on the size and structure of the molecules of proteins, as well as upon the molecular weights of certain enzymes, carried out with the aid of Svedberg's ultracentrifuge, constitute a new and promising application of physics to medical research and valuable work has been done with it in connection with blood pigments and serum proteins. It may be helpful in the study of immunology and the physical chemistry of blood.

Ophthalmo-eikonometer.

The Ophthalmo-eikonometer has been developed for measuring the size and shape of ocular images and has opened up a new field in ophthalmology, psychology, and neurology. It consists of the study of image size variation in binocular vision.

A technique has been developed, 'by means of which the brains of mammals can be stimulated at accurately defined points and a correlation established between the locus of stimulus and physiological function'. Interesting possibilities lie in the determination of the influence of certain parts of the brain over some of the organs of internal secretion and over the functions of the gastro-intestinal tract, the kidneys, etc.

A method has been recently evolved which permits observation of the form and behaviour of living cells providing a valuable means for studying nervous control of the circulation and the nature of nerve destruction and regeneration.

Micro-manipulator and Micro-dissection.

Operative work on the living cells has long been the aim of investigators in cytology and in experimental embryology. By micro-dissection and injection the physical structure of protoplasm has been determined by Chambers and others. Until recently the results obtained by the micro-dissection method related to the viscosity, the differentiation of cortex and interior, the nature of the surface film, the nature of chromatic and achromatic structures in dividing nuclei, internal and surface changes influencing cell division, protoplasmic changes accompanying fertilization, and the effect on protoplasm of the injection of certain substances.

One of the most important applications of micro injection methods for the study of cell-physiology is the rôle of electrolytes in the maintenance of protoplasmic structure and function. K and Na are far more toxic when applied externally than when

injected, the order of toxicity for the immersion experiments being K, Na, Ca, Mg. $CaCl_2$ is considered to have the most marked toxic effect on the internal protoplasm. $MgCl_2$ is considerably more toxic to it than either KCl or NaCl. From the above and similar experiments, it is presumed that the maintenance of the colloidal state of living protoplasm depends upon the presence of definitely proportional amounts of different electrolytes. The relative amount of different types of salt present must be in such proportions that the solidifying action of the one is balanced by the dispersive action of the other. K is said to be a labiliser while Ca is a stabiliser. Ca is essential for the formation and maintenance of the protoplasmic membrane.

The determination of the hydrogen-ion concentration of protoplasm has been considerably developed in recent years by micrurgical technique. Both colorimetric and potentiometric methods are possible for the determination of the pH of protoplasm by the use of micro-electrodes. By means of this technique it is found that the living protoplasm of widely different types of cells has, under normal conditions, a remarkably constant pH value. The technique has also rendered possible the study of the oxidation-reduction potential of protoplasm.

The recent investigations in micro-dissection of human polymorphonuclear neutrophiles show no marked divergence from Chamber's excellent description of the physical structure of cells in general. It would seem, however, that the cell membrane, in this case, is more rarely a naked surface film than he ascribes to most cells. The cytoplasm is more liquid than that of the monocyte and clasmatocyte.

Observations by micro-injection method on plant nuclei show evidence of an elementary structure together with a fluid sap in the resting nucleus and supports the view that, in plant cells at least, a persistent frame-work exists which might account for the genetic continuity of the chromosomes.

Radiology.

X-ray diagnosis has improved in the present day to an almost spectacular extent; and radiation therapy has now established its claim to an important place in the treatment of malignant disease.

One of the recent advances in diagnostic radiology is undoubtedly the introduction of cholecystography by Graham and Cole. The radiologist can now visualize the biliary tract and the gall-bladder by means of tetraiodophenolphthalein; by the injection of air he can outline organs in the abdominal cavity and the sinuses of the brain. By the use of organic compounds of iodine he can make visible the lungs, the air passages, the interior of the uterus, the spinal canal, the pelvis of the kidney and the urinary tract, and, by the use of a radio-active substance called thorotrast, the tissue of the reticulo-endothelial system including the spleen and the liver. Cerebral angiograms may

also be taken by means of this substance for the purpose of localizing brain tumours. Modern fluorescent screen enables digestive movements, heart beats or lung movements to be watched or cinematographed. Placenta prævia has also been brought within the possibilities of radiological diagnosis.

Perthes has found that the intensity of radiation falling upon a surface perpendicularly is inversely proportional to the square of the distance of the surface from the focal point of the target of the tube. The cumulative effects of Roentgen rays were also studied by him, as also the fact that harder X-rays produce a longer *latent period.* He observed that X-rays as ordinarily used are composed of mixed rays and filters were first introduced by him to cut off softer rays.

By the standardization of physical and biological doses and the proper intervention of filters the dangers of radiation therapy have been greatly reduced in recent times. Today with the improved technique and modern equipment we can safely work with rays of much higher intensity than before without the slightest danger to man, mind and machine.

X-ray and radium therapy is bidding fair to displace the knife in the treatment of certain forms of cancer. The response of tumours to radiation demands wide study, each type of tumour having a different response, both clinically and histologically. By contrasting the sensitivity of growths with that of skin—in both cases using the minimum lethal dose as the standard—it has been possible to place tumours in different groups—radio-sensitive tumours, epitheliomata, adenocarcinomata and radio-resistant tumours.

Views on radiation treatment have changed today and the single massive dose of X-radiation, advocated in former days, is now replaced by a series of smaller doses spread over a period of time. The real problem of malignant disease lies in the treatment of glandular metastases. For deeper lesions and gland areas we turn either to (*a*) X-rays which, excited by very high and ever-increasing voltages, tend to approach γ-rays in quality, or to (*b*) large quantities of radium placed at distances remote from the skin with the object of obtaining the large depth doses possible with X-rays.

The growing belief in the efficacy of 'teleradium' is indicated by the rapidly increasing number of large radium units being set up in the world. It is to be hoped that with advances in the technique of teleradium and deep X-rays, better results may be obtained in future in the treatment of cancer.

With improvement in apparatus and technique it has now been possible to distinguish radiologically the softer tissues of the body from each other and the extent of invasion of new growths in them.

Though the explanation of chemical, physiological and morphological changes in normal and pathological tissues on

irradiation is very scanty in the present state of our knowledge, yet there is a promising beginning as will be seen in recent developments on the subject, especially in great laboratories in America, such as, the Mayo Clinic, Rockefeller Institute and the foremost medical schools. Special radiosensitiveness of cells has received emphasis in the hands of Desjardins and others.

I may just say a word about the application of X-rays to genetics. The origin of the new genes by mutation has been shown to be speeded up at least two hundred times by X-rays.

Radium and artificial radio-activity.

Lawrence of the University of California has succeeded in producing a radio-active form of sodium from common salt, having remarkable properties. This will enable sodium to be introduced safely into the animal system, and is likely to be of great value in medicine. He has announced that it would soon be possible to produce cheap radium for commercial purpose and it has been claimed that the discovery of artificial radio-activity in elements, otherwise inactive, will be of greater importance in medicine than the discovery of natural radio-activity. Proto-actinium may have valuable therapeutic properties. The new artificially produced radio-active elements may before long replace the costly radium for therapeutic purposes and for the study of many biological processes.

Light therapy and Electro-therapy.

I have already mentioned the uses of the ultra-violet and infra-red rays photography as an aid to medicine. They have also had therapeutic applications in modern times. It is generally considered by many authoritative observers that ultra-violet and infra-red rays modify each others' effects on the living organism, according to their several proportions in combined relations.

Short-wave and ultra-short wave therapy is one of the latest branches of physical therapy. It is not my intention to give an account of the various branches of electro-magnetic wave therapy. I shall only very briefly refer to short-wave and ultra-short wave therapy.

The better results claimed for the very powerful short-wave instruments may be partly explained by the greater capacity effect obtained in the tissue as the wave-length decreases.

It has been inferred that the more delicate the structure, either of cells or micro-organisms, the greater would be the disruptive action of short and ultra-short electromagnetic vibrations.

Though some observers hold that there is very slight or even total absence of appreciation of heat during the administration of a short-wave treatment which may be followed by most satisfactory results, yet many attribute the whole action of ultra-short waves to the heat action. They state that experiments which have been carried out *in vivo* and *in vitro* show

that they have no specific action on bacteria or tissue-cells and they have observed that bacteria soaked on to a piece of gauze, placed under the skin of animals and exposed to ultra-short waves are undamaged with lethal doses of ultra-short waves, and there is no change in fragility, sedimentation rate, and bactericidal power of the blood following exposure *in vitro*. They conclude that the action of ultra-short waves appears to be coagulative necrosis and extreme vaso-dilatation, which is similar to the action of diathermy high-frequency currents of about 300 metres.

Whatever may be the exact mechanism by which short-wave or ultra-short waves show their therapeutic effects, there is no doubt that the advent of short-wave therapy opens up a field of treatment of great possibilities hitherto totally unexplored. It has been held by some that the outstanding difference between long-wave diathermy and short-wave therapy is the peculiar effectiveness of the ultra-short wave in infections and in conditions of suppuration, where diathermy is definitely dangerous, that this quality belongs only to the ultra-short waves of from 6 to 3 metres and that between 15 and 30 metres there is only heat effect.

I shall not detain you by discussing the principles of diathermy or the various forms of light therapy as they are beyond the limits of my thesis. It may be said in brief that the rays of different wave lengths and frequencies have come into modern practice for the treatment of many diseases with excellent results.

I hope that advances in photo-dynamic sensitization may in future lead to the discovery of therapeutic substances which will be activated by the short infra-red, luminous, red, and orange rays and act as sensitizers in the presence of blood-serum.

When we survey the immense development in the use of light waves, visible, ultra-violet, X-rays, and others in the investigation of structures and the treatment of disease, with their future potentialities, it may be said without conceit—truly we are beginning to see through a glass less darkly.

Bragg-Paul pulsator. Artificial respiration.

Among the many useful apparatus which physics has placed at the disposal of medicine in recent times for therapeutic purposes, I would like to mention here, as an example, one devised for prolonged artificial respiration. There has been of late an increased scientific interest in artificial respiration methods. The one mentioned here has been designed by Bragg and Paul and is known as Bragg-Paul Pulsator. It shows the triumph of an artificial apparatus in maintaining one of the most vital functions of the body, i.e., respiration, which it is unable to perform due to a physical disability. There are some conditions, arising both from

accident and disease, in which long-continued and regular artificial respiration is required. Bragg-Paul Pulsator consists of a pulsator which rhythmically inflates an air-bag encircling the bony thorax of the patient below the armpits to a definite air pressure as indicated by a manometer. Although the lengthy need of an artificial respiration apparatus is rare, still it must prove very satisfactory in cases where its use is indicated. In one case a patient had artificial respiration on this principle for over two years with satisfactory results.

Geology.

The geologist has discovered numerous spas and springs which refresh and renovate the human system today. In schemes of drainage and irrigation, and of water-supply in general, that are bound up fundamentally with the health of mankind, the public health departments of civilized countries all the world over, look forward to the aid of the geologist. It is perhaps known to you that in one section of a town in an English county, the effects of calcium deficiency among most of the children were traced by the geologist to the poor-in-calcium drinking water of the clay zone area of the town. In the investigation of silicosis, a disease prevalent chiefly among miners, we find the physician working hand in hand with the geologist who has been charged with the identification of the minute particles of mineral matter that find their way into the lungs of the miner. The application of the geologist's methods has led to the detection of china clay and talc in adulterated food-products. In the investigations of the dust problems in big cities, the aid of the geologist is indicated. Endemic goitre has been traced to iodine deficiency in drinking water. Excess of iron may give rise to an endemic disease, the 'so-called mottled enamel' in man and some animals in certain places, such as Algiers, Tunis and others.

Psychology.

Mental disease, before the advent of psychology in medicine, was a *terra incognita*. Recent researches in psychology have thrown a flood of light on the domain of psychiatry. The significance of a mental approach to the problems of psychology had long been misunderstood, but today not only we have a better understanding of mental diseases by means of the psychological method but also we get extremely encouraging results in the treatment of such disorders and psycho-therapeutics has found a place in the armamentarium of the medical men.

I do not know whether one would agree that the services of Freud to knowledge have been as great as those of Darwin,

and whether Freud's extension of the idea of sex will stand the test of time, but there is no doubt that one of the greatest contributions to medical psychology in recent times is the concept of the dynamic unconscious. To trace the genesis of mental disorders one has to dive deep into unconscious region of the mind. That the mind has an unconscious component was not at first accepted by physicians trained in the orthodox school. Awareness is not an essential characteristic of mental process. Significant changes may go on in the mind without our being conscious of them. It is in this unconscious region that the roots of mental disorder lie.

It has been recognised that the explanation of many fully conscious occurrences—which had previously been left unexplained as simply coming 'out of the blue'—might be found in this dimmer region. It was from this region of the mind Lady Macbeth uttered 'Here is the smell of the blood still; all the perfumes of Arabia will not sweeten this little hand'.

Attention has now been concentrated upon what might be described as the border region between the psychical and the physical. In fact, some of the psychologists—the behaviourists —might be said to have gone over the border-line altogether and merged the psychical in the physical, but those medical men who have come back again to their own special domain *via* psychology of this kind, have been disposed to view the physical from the psychological point of view. Today a firm alliance has been concluded between medicine and psychology, and medical men have more and more fully recognised the necessity of studying the mental history of their patients. Much work has been done in the study of the unconscious in many institutions, notably, the Nancy School. The aftermath of the great war was seen in many cases of nervous debility which are treated in famous clinics *e.g.* of Hadfield and others. The power of the instincts and the inhibition of the latent forces, of their release, as well as the phenomena of fatigue, have been thoroughly studied to the great advantage of medical practice and efficiency. Modern psychologists and medical men are paying more and more attention to that aspect of psychological investigation of the bodymind known as sublimation of instincts and emotions. Many medical men at the present day devote themselves as specialists to the practice of psycho-therapy.

It may be that the theories of genetic inheritance perhaps apply partially at least to mental characters. It is important, as Dawson has stated, that the latter should be distinguished and the manner of their inheritance traced out. Much work is being done in recent times for diagnosing and measuring unitary mental traits with the view of satisfactorily studying the genetic basis of mental traits. In this respect the co-operation of the medical man, the psychologist and others is imperative.

To some psychologists there is nothing more noticeable in recent years than the *rapprochement* between medicine and psychology due to a fundamental cause. They hold that partly this fundamental cause is that the ultimate character of reality is mental, and that the days of scientific materialism are gone which ruled over advancing thought in the last quarter of the nineteenth century, under the leadership of Huxley, Spencer and those who thought with them. The attempts to explain all phenomena in terms of matter, which were in vogue half a century ago, have been considered to be unsatisfactory by those who hold that mind is no longer to be either ignored or compelled to wait in the ante-chamber assigned to non-descript characters called epiphenomena.

The effect of this has been seen amongst medical men and has made them more disposed to admit a close association between mind and matter. It is recognised by them that mental factors are amongst the most important, and that these may be treated with a considerable prospect of success.

In the present day, it is all to the good that man should be treated as a unity of body and mind, instead of being handed over as it were to rival practitioners—to medical men on the one hand, and to the psychologists on the other. Therefore the alliance between medicine and psychology is to be welcomed. It is fitting that medical men

> 'Should study passion; how else cure mankind
> 'Who come for help in passionate extremes.'

> 'Who could express with more prophetic vision this subtle relationship better than he who was both poet and physician . . . . . for in truth the mind is undissociable from what it contemplates.'

Mathematics.

Bayliss once remarked that the ultimate aim of all sciences is to express in a mathematical form the discoveries that have been made in them. Though it is a difficult problem to express all facts in medicine in a mathematical equation, yet the application of mathematics to medicine is increasing in recent days.

Within recent times nomograms or alignment charts have been constructed for finding the total number of calories contained in any diet of known composition, for respiratory quotient, and for colour index of blood. Observers have worked out more or less elaborate mathematical methods for building up a suitable diet for any particular diabetic patient. These have been calculated on a knowledge of the so-called basal metabolism needs of the patient, his body weight, height and surface. The vitamin requirements of man have been put in a mathematical formula. The curve of healing of a wound was developed by Carrel and others during the war.

Various equations and curves have been formulated in connection with disease, such as the periodicity curves of epidemics, theory of happenings in its application to epidemic and endemic diseases, of life tables and of carriers of disease. The latter is of special value in India. I need not dilate upon them in detail here any further.

It has to be remembered that the application of mathematics to medicine has its limitations. All patients do not react in exactly the same way and some subjects appear to be beyond the control of mathematical formula. The various tables and curves used in modern work are no doubt of great scientific interest but they have their limitations.

Undetermined factors exist in more exact sciences like physics and chemistry. It is therefore to be expected that the same might be still more manifest in the science of medicine which has to deal with diseases of the body and mind and in which there are many complicated and undetermined factors to operate. In investigating a science which deals with diseases of the mind we have to employ our mind to tell us about itself, and this we must do as a necessity, since we have no other instrument with which to conduct our investigation. Mind is therefore both executive and judicial, it is both judge and jury in its own cause. In such a science there must be many undeterminable factors.

Concluding Remarks.

Forecast.

From what I have stated, it is clear that the various sciences can be of great service to MEDICINE. Some of them have contributed very substantially to the relief of human suffering from disease. They can obtain valuable findings for the clinician in diseased conditions which may be helpful to him, but the responsibility finally rests with him as to how to act upon their findings. This shows the great importance of what is called today Clinical Science. Anatomy the science of structure of the body, physiology the science of function and the meeting ground of physics and chemistry in their application to problems of health and disease and biochemistry the science concerned with the chemical processes underlying the activities of living matter, can be of great service to the clinician. In recent times, the need for increased application of physics and chemistry to medicine has grown with tremendous rapidity.

'The aim of all medical science is to control suffering, to prolong life and to keep mankind in a state of vigorous health'. The science of MEDICINE, which was once mostly limited to the study of disease, is now concerning herself with the study

of health, by the increasing knowledge of nutrition, environment and eugenics. Though some may say that mathematics or metaphysics is the queen of sciences, yet I hold that MEDICINE is still another or more properly speaking, she is supreme among the queens of all sciences. I hope that all your sciences will serve her duly and to her best advantage, so that the person who professes her may give more and more relief to his patients in the mitigation of their sufferings by the light that he gets through your agency.

The newer conceptions of life advanced in recent years have opened our minds as to the nature of the living organism. Evolutionally, we see life adapting itself to many varied conditions and to considerable extremes of environment. The most versatile is man who is found from pole to equator. His capacity for adaptation has been achieved and can be maintained only by the possession of an almost changeless and constant medium, the blood, which acts as the direct environment of his most valuable possession, namely, the brain. Man's whole body mechanism is organised in order to preserve '*La fixité de milieu interne*' as it was called by Claude Bernard. One hears in physics of the so-called constants of nature such as speed of light or Planck's constant, but surely the level at which the essential blood constituents are maintained may also with justice be called the supreme constant both of and for *Homo-sapiens*. It is no passive state; dynamic equilibrium holds it where it is, and it preserves for us the sole condition for the progress of the development of man and his civilization. And when disease sets in, MEDICINE comes to his aid to maintain this constant or else he may deteriorate and die.

> 'Yea and how delicate. Life's mighty mystery . . . . all its self propagating organisms exist only within a few degrees of the long scale ranging from measured zero to unimagined heat . . . . . . Nor could they endure wore't not that by a secret miracle of chemistry they hold internal poise upon a razor edge that may not even be blunted, lest we sicken and die.'

In million million years, the earth's temperature may be reduced to such an extent that it would be rash to predict how such a fall of temperature may affect man's life. What then will be his blood constant ? I can not say. If then he lives, MEDICINE will still be called upon to mitigate the diseases that may attack man in that dim distant future.

It is immaterial for the purpose of my thesis whether the universe is fast proceeding to dissolution and death, by the rapid increase of entropy, according to the laws of thermodynamics and along with which man will meet the same fate, or whether creative evolution will lead in millions of years to the production of superman with new superkingdoms which are beyond the limits of our imagination. But whatever that may be as

long as man exists, MEDICINE will have to deal with the infirmities of the degenerate man or the superman, as the case may be.

The discoveries in MEDICINE and its ancillary sciences in recent times have been phenomenal. We do not despair and say what Richet has said in the 'Impotence of Man' that 'with the aid of a few drugs, we succeed in minimising for a time a few trifling morbid phenomena which cause us discomfort'. As Du Nuöy has stated, a day may come when the methods of treatment, generally used today, will appear to us as gross as do now the methods of Mr. Purgon, of Molière's 'Malade imaginaire'.

Who knows what the future of MEDICINE after ten or hundred thousand years will lead to. Perhaps, in æons to come, it will be the conquest of old age and in complete immunity from disease. Could we not dream of a day when one shall see 'all diseases quenched by science, no man halt or deaf or blind'. What sort of bodymind will then be evolved, I shall not speculate to say.

But man's destiny may take a different and darker turn in future. Newer diseases worse than cancer or plague or the worst virus disease of today may attack him in the future. Circumstances over which man may have no control, may lead to the deterioration of his body and mind resulting in the creation of newer maladies. These may render the task of MEDICINE more and more difficult. Catastrophies may occur in the world and civilization may regress. Such a cataclysm may be a geological one or due to a devastating world war much more terrible than is ever known in history or to a fatal epidemic which may spread from one part of the world to another with terrific rapidity or as Spengler and others hold, it may be a cyclic process passing through the alternate periods of growth and development on the one hand and decay on the other, as evidenced by the various ancient civilizations of the world which have now ceased to exist. But whatever that may be, 'MEDICINE and civilization will advance and regress together' for all times to come.

The contribution of MEDICINE to civilization aided by the other sciences is great. A healthy body means a healthy mind, and such minds are less likely to cause internal or external strife. There is no doubt that a large part of the greatly increased comfort and safety that we enjoy today is the result of the phenomenal advances that have been made in the medical sciences in recent times. I would say with Howard Haggard 'And finally the physician'. He rightly holds that 'Medical history discloses the forces that have made our modern civilization possible . . . . That modern medical science is today one of the strongest forces operating for human betterment—it is the religion of healthy childhood, manhood and womanhood'.

In spite of recent occurrences, will not a day ever come when one may say that

> 'The war-drum throbb'd no longer,
> And the battle-flags were furl'd
> In the Parliament of man, the Federation
> of the world'?

I conceive such a day may come and that slowly and slowly, physical warfare will give place to warfare of the intellect. There will be no jealousy, and superiority or inferiority complexes will cease to exist. Slowly and slowly, man will live not by the destruction of the lives of his neighbours and seizing their property, but by making every part of the world healthy and habitable by improved methods of hygiene and thereby minimizing the need for the control of population, the overgrowth of which has been considered to be, to a great extent, responsible for many wars of the world. There will be no inadequacy of food supply which has led to many wars of aggression in this world.

With his conception of the horrors of war, the MEDICAL man is a fit person for preaching the gospel of abhorrence of war. He can depict to you scenes in which, with his Sisters of the Red Cross, he picks up the wounded from the battlefield in the midst of most frightful agonies and tries to extract a bullet from the heart or the shattered brain or to transfuse his own and his assistant's blood into the vein of a dying soldier when the guns are roaring in the battlefield, irrespective of whatever camp he belongs to. I hope that in every peace league of the world, the MEDICAL man may have some representation, not as a diplomatist, but as one whose motto is that the well-being of mankind throughout the world should be effected without any destruction of life. A day may come when the war mentality of individual statesmen, which may lead to war psychosis among the people, will be analyzed and corrected by the psychiatrist and the psychologist. In this connection one welcomes the recent manifesto issued by the Committee for War Prophylaxis of the Netherlands Medical Association.

Could we not dream of a day when economic depression and unemployment will be ended, thanks to the increasing scientific development of newer industries and newer field of fruitful work, and there will be leisure to enjoy the beautiful fruits of the earth that science may provide, and when man relieved from toil by his mastery over the great sources of power in Nature, will have the opportunity of being richer, happier, healthier and freer than ever before. I conceive that this is possible if, as Jeans has suggested, there is a proper balance between labour-saving devices and industry-increasing discoveries. MEDICINE, which includes preventive medicine may help here in its own way by eradicating and preventing disease and thereby increasing man power and the capacity of the

people for work, for taking part in the development of newer industries and agriculture, and for defending the country in times of need.

If one studies the evolution of man, one finds that his intellect is growing out of proportion to his body. The caveman was perhaps stronger in bodily strength than the strongest man of today. Is it possible that man's body may become smaller and smaller, his fierce, destructive, and other base instincts and feelings may be sublimated and his mind grow more and more and in the æons to come become independent of matter? Even then MEDICINE will minister to the 'mind diseased' in which perhaps physics and chemistry may have no part to play. Or is it possible that after reaching its zenith of development, the mind may begin to regress and body begin to grow and thus a perpetual cycle may continue in which body and mind may alternately undergo growth and decay for eternal times? Or is it possible that, finally, the mind of man may merge into the eternal and infinite Mind and feel '*Soham*' (सोऽहम्), i.e., I am He.

If in dealing with my subject, I have sometimes drifted to a mystic region, I would justify myself by repeating what Einstein said 'It is enough for me to contemplate the mystery of conscious life perpetuating itself through all eternity, to reflect upon the marvellous structure of the universe which we can dimly perceive, and try humbly to comprehend even an infinitesimal part of the intelligence manifested in nature.'

Some of you may perhaps say that 'the progress of science does not afford any evidence that the behaviour of living matter is governed by any other than the laws of physics and chemistry' (Bertrand Russell). But who can deny what Gowland Hopkins once said that 'there may be yet higher levels calling for discussion in quite different terms'? The mechanism of life can not be explained by the physics and chemistry of today, though perhaps some of it may be explained by some ultra-physico-chemical laws that may be discovered in the future. Even then one may not be able to say wherein, from the radiations to the bodymind, enters the breath of life.

The bodymind of man is the finest product of the universe even when compared with the most magnificent of the stars and the nebulæ. Man's appearance cannot be regarded purposeless or accidental or as a sign of disease. He has discovered the laws of motion and of relativity as well as of radio-telegraphy, radio-telephony, aviation and television. He unfolds the constitution of the stars and the nebulæ, millions and millions of miles away from the earth. He calculates the weight and temperature of the stars and determines their ages. He finds out the constitution of the atoms and discovers the cosmic rays. He smashes the atoms and produces new radio-active elements. He transforms one element into another. He may, one day, be able to determine the mathematics of the atom by means of his

calculator. He tries to find out when and how primordial life came into existence. He tells the story of the oldest man who existed in the earth a million years ago, and gives the history of his evolution. He discovers the chromosomes and finds out the structures that are responsible for heredity. He discovers and dissects the micro-organisms of disease, and finds the defensive mechanism against their attacks. He studies the specific carbohydrates and proteins, and tries to discover the structure of the viruses and the bacteriophage. He discovers the treatment of diseases once considered incurable. He records the electric changes of the brain cortex of man in various cerebral states, and may one day record human thoughts on a sensitive plate. He studies the endocrine glands, and synthesizes their secretions. He may one day be able to influence the sex of the embryo at his will. He cultures the organs of the body and studies their growth *in vitro.* Ponce de Leon did not perhaps search for the impossible and unattainable when he sought the fountain of eternal youth, for man may one day conquer old age, disease and death. Though I dare not say what the 'final secret' is likely to be, yet the bodymind of man must be today the consummation of the work of the Great Design. In this most complicated machine in which, it may be said, 'matter, life and mind translate roughly into organisation, organism and organiser (Smuts),' MEDICINE tries to give the healing balm to act as a powerful agent for the maintenance of harmony and strength when disease sets in.

Let me now tell you what MEDICINE may do in other directions.

In the present day one cannot fail to be struck by the great increase in the varied functions that have come to be regarded within the province of the MEDICAL man. 'He has in large part taken the place of the parson. He has made encroachments on the functions of the lawyer, the legislator and the judge, of the schoolmaster, the architect and the statistician. He has assumed some of the duties of the parent and guardian, while even the soldier and the policeman are to some degree under his control. In the ordering of their lives, and even in the regulation of their vices and the reform of their shortcomings, men and women are far more willing to seek the advice and help of the medical man than once they were. The reason is, without doubt, that his advice is much more worth having than it once was' (Singer).

Lastly there is that wonderful influence of the mind of the true PHYSICIAN upon his patient's body and mind. The influence has been well expressed in the following words: 'Nothing can take his place—not priest nor minister nor all the clinics that science can provide. There is a rapport and a confidence between him and his patient which has been known

to accomplish miracles.' If this force exists, I call it '*personalitism*', the force that mind may exert upon mind, body and disease.

Thus we see that the functions of the MEDICAL man are manifold. Still with all humility he says

'If I can ease one life its aching
Or brush away one pain
If I can stop one heart from breaking
I'll not have lived in vain.
If I can help one failing brother
Into his strength again
If I can calm one fretted mother
I'll not have lived in vain.'

I am afraid my address is 'not much better than that noise or sound which musicians make while they are tuning their instruments. . . . . So I have been content to tune the instruments of the Muses, that they may play that have better hands' (Francis Bacon).

Section of Mathematics and Physics.

President:—Dr. T. Royds, D.Sc., F.N.I.

Presidential Address.

SOME SOLAR PROBLEMS.

Without the sun we should have neither food to eat, nor yet sufficient warmth to keep us alive. Although the sun is a vital necessity for the existence of all forms of organic life on this earth of ours, this is not the only reason why the physical constitution of the sun has been for long a question for detailed investigation by astronomers. The stars and planets have been a favourite object of study by mankind for untold centuries. Our later studies of the stars have called attention to the fact that in the stars physical processes are taking place under conditions which are not available in any earthly laboratory. In the interior of stars the atoms are exposed to temperatures and to radiation transcending any conditions which we can produce in the laboratory. If the properties of matter under these extreme conditions can be studied, we shall better be able to understand the properties of matter still mysterious to us in our laboratories, and perhaps be able to apply our understanding for the use and benefit of mankind. But whatever may be our ultimate reason for studying the stars, they are so far away from us and the light from them is so faint when it reaches us, that an intimate knowledge of them must always be a matter of difficulty. The stars are so far away that they appear to us as mere points of light and no telescope, however powerful, can bring them near enough to let us see their surfaces. We are however favourably situated as regards one star, namely the sun. We are so close to the sun that we can see its actual size in the sky. It is the only star whose surface we can study. The phenomena which we can see on the surface of the sun reveal to us the conditions prevailing in the outer envelopes of stars, which must have been hidden from us if we had not had the sun's surface available to us to reveal their possibilities. Whether or not it is a mere accident which has placed us near enough to one star to see its surface, our knowledge of the stars in general owes a great deal to the fact that we can make a detailed study of one of them.

In selecting the solar problems which I might bring to your notice I have been largely influenced by investigations made at the Kodaikanal Solar Physics Observatory in South India, and the problems I mention below are some of those which have recently occupied much of our attention in that Observatory.

The first problem relates to prominences. Let me recall, in a glance, the appearance of the sun's surface as it can be seen with modern instruments. The surface of the sun which we see with the naked eye, with or without a telescope, is called the photosphere. On this surface are seen the well-known sunspots, and we cannot see deeper into the sun, although it is entirely gaseous, than this surface. This photospheric surface emits a continuous spectrum corresponding to a temperature of 5740°K. Its spectrum is crossed by a large number of absorption lines, called, after their discoverer, the Fraunhofer lines. They are caused by an envelope some hundreds of miles thick, known as the reversing layer and consisting of most of the known terrestrial elements. At a total eclipse of the sun the moon gradually blocks out the sun's disc from our view but as it advances far enough to cover the photosphere completely, the reversing layer remains uncovered for a few seconds before it, too, is covered by the advancing moon. During these few seconds the reversing layer is seen without photospheric background and it consequently shows now as an emission spectrum, known, on account of its short duration, as the flash spectrum. Thereafter, a still higher envelope some thousands of miles thick, called the chromosphere because it is coloured, and a more extensive but fainter envelope called the corona, remain visible throughout totality. Outside of a total eclipse the corona cannot be seen, although some partial success in observing the corona in full sunlight has been claimed by Lyot. The chromosphere, on the other hand, can be seen and photographed by means of the spectroscope and of its applications as a spectroheliograph and a spectrohelioscope. The spectroheliograph, for example, can easily reveal the chromosphere in full sunlight, using the light of either ionized calcium or of hydrogen, by covering up the photosphere with a disc to make an artificial eclipse of the sun in order that a long exposure can be made on the chromosphere alone. Either by the spectroscope and its applications, or at eclipses, some prominences can always be seen extending to considerable heights above the chromosphere at different places on different days. The spectroheliograph can also reveal on the disc of the sun, dark markings which are quite distinct and different from sunspots. Ever since the discovery of these dark markings it has been recognized that they must be closely related to the prominences at the limb of the sun.

The Relation between Prominences and Dark Markings.

One of the problems which has been studied at the Kodaikanal Observatory has been the nature of these dark markings referred to above, and their exact relation to the prominences

at the limb. The majority of the dark markings are long and narrow, and lie in a direction inclined to the lines of longitude and latitude with the end nearer the equator more westerly than the end which is nearer the poles. Moreover, this average inclination depends on latitude. Those near the equator lie almost north and south but in higher latitudes they incline more and more with the polar end towards the east until in latitudes higher than about 40° they lie nearly east and west. The cause of this inclination is the polar retardation in the sun's rate of rotation. Since the higher latitudes rotate more slowly than the lower, the polar end of a dark marking will, as time goes on, lag behind the equatorial end. This is well shown by the long straight marking of August 1927 illustrated in Kodaikanal Observatory Bulletin No. 89. It crossed the central meridian on August 2nd inclined at 40° ; after a complete rotation of the sun it was again crossing the central meridian but with its inclination increased to 55°.

Apart from any other interest, the variation of the inclination of dark markings has proved a great practical convenience in studying them. For example, those lying along a parallel of latitude cannot be used for determining the speed of rotation of markings but those which lie in a direction approximately north and south give the most precise values. And again, the latter kind is useless for comparing with width of a dark marking with the width of a prominence whilst the former kind is more suited for this purpose. We shall see later on, that markings which lie neither north and south nor east and west, but in some intermediate direction, also have their uses.

Another feature of dark markings as shown in hydrogen spectroheliograms is the fact that on each side of the length of the dark markings, there is a bright margin. These bright margins are seen with greatest contrast when the marking is near the limb, but in this case the margin on the limb side is hidden behind the higher projecting dark marking. The relation of these bright margins is not yet completely understood. They are at a lower level than the dark marking, yet they are not evidenced in calcium spectroheliograms and are not shown in photospheric light.

That there is an intimate relation between dark markings and prominences has long been recognized and is shown by the two following facts : (1) a prominence is nearly always seen where a dark marking touches the limb, and (2) when a well-marked prominence has been seen at the east limb, a dark marking is seen on the disc after a few days. A problem we have tried to investigate at Kodaikanal is the exact relation between the two, the prominence at the limb and the dark marking on the disc. A great difficulty arises from the fact that when an individual prominence is compared with its associated dark marking, inconsistencies prevent much progress.

A time interval must elapse between the dark marking being visible on the disc and the prominence appearing at the limb and it would seem that changes and movements in this time interval thwart consistent comparisons.

Most progress in the comparing of dark markings and prominences has been made by considering averages, especially the average heights of the two phenomena. The height of a dark marking above the surface of the sun can be deduced either from its changing area as it approaches the limb, or from its apparent motion in longitude. If a dark marking lay flat on the sun's surface, its apparent area would decrease near the limb on account of foreshortening. The change observed is actually the contrary, namely the area increases near the limb compared with the centre. This increase is due to the fact that the dark marking has a height above the surface of the sun, and the rate of increase is a measure of the height. Mr. Salaruddin has given in Kodaikanal Observatory Bulletin No. 96 his measures of the rate of increase of the areas of dark markings as they pass across the sun's disc, and the average height of a dark marking above the surface of the sun he finds to be 31″. The average height of prominences at the limb is known to be about 36″, which is sufficiently good agreement with the height of a dark marking.

The other method of deducing the heights of dark markings depends on a discovery by d'Azambuja that they show an acceleration in the apparent speed of rotation when near the limb of the sun. Now the actual speed of rotation can be found from the time occupied by a complete rotation of the dark marking, and it is found to be about the same as the speed of sunspots. The apparent acceleration near the limb was interpreted by d'Azambuja as due to the height of the dark marking above the surface of the sun and he deduced their height from measures of the apparent longitudes near the limb. It is my experience that measures of longitude near the limb are subject to large errors, and consequently I have found it more convenient to measure the time required for a dark marking to pass from the central meridian to the limb, and vice versa. Dark markings which lie in directions between north (or south) and east are most suitable for these measures. It is a simple matter to measure the latitude where such a dark marking meets the limb at the time when a photograph was taken. The time when this part of the marking was exactly at the central meridian can be deduced accurately from the photographs taken when the marking was near the central meridian. The time interval required to pass from the central meridian to the limb, I have called the quadrantal time for the latitude measured. If a dark marking lies flat on the surface of the sun the quadrantal time would be exactly one quarter of the time required for a complete rotation. Now a complete

rotation (synodic) of a dark marking takes 27·27 days, and a quarter of this is 6·82 days. The quadrantal times are however less than this by an amount which measures the height of the dark marking above the surface of the sun. The average quadrantal time found is 5·55 days, that is it requires one and a quarter days less for a dark marking to pass from the central meridian to the limb, and vice versa, than for a quarter rotation of the sun. This corresponds to a height of 33·5″ above the surface of the sun, a value which again is in surprisingly good agreement with the average height of prominences at the limb. The result mentioned above applies to the edge of a dark marking which is nearer the limb than the centre. This is the highest part of the dark marking. The other edge, which is nearer the centre than the limb, corresponds to the lowest part of the marking. It is surprising to find that the quadrantal time for this edge implies that it is at a considerable height above the surface of the sun; indeed the bottom of the marking is only 5·5″ below the top. This has not yet been fully explained but I believe that the cause lies in the way the measures have been taken, namely that whilst they give the highest part of the marking correctly, they tend to select as the lowest part portions which are not actually reaching down to the surface of the sun.

Some further measures are at present being made at Kodaikanal which will help to trace the connection between dark markings and prominences, but so far as the above results go, the evidence shows that the dark marking and the prominence are merely different aspects of the same identical solar phenomenon. Perhaps this may seem a somewhat tame conclusion of what was only to be expected. Yet anyone who has endeavoured to trace the connection between the individual prominence and its associated dark marking would, I think, find that their identity was by no means obvious. If we are convinced of the identity of prominences and dark markings, the prominence being a kind of profile at the limb and the dark marking being a kind of projection on the disc, so that the two are merely different aspects of the same feature of the sun, it follows that the typical characteristic of this feature consists of a narrow line of flame extending along a considerable length of the sun's surface. This line of flame has a width of about 7,000 miles, an average height of 14,000 miles, but of a length enormous compared with these dimensions and often amounting to 400,000 miles or more.

The Support of the Sun's Chromosphere

Another solar problem to which we at Kodaikanal have devoted much attention is the question of the supporting force of the chromosphere. The chromosphere extends to heights

far greater than can be supported by gas pressure. The height of the chromosphere can be measured in various ways. One method is to measure the distance of the top of the bright hydrogen line in an undisturbed part of the chromosphere above the continuous spectrum. This gives a result of the order of 10″, or 7,250 kms. Another is to measure the diameter of spectroheliograph images of calcium or hydrogen light compared with the diameter of the image taken with the neighbouring continuous spectrum ; for hydrogen this gives a height of 6·3″.

The measures which are obtained at total eclipses give heights which are greater than these because the glare of bright sunlight without an eclipse prevents the upper limit of the chromosphere as revealed during an eclipse from being reached. The greatest heights for the chromosphere are therefore recorded at eclipses. These heights are measured from the lengths of the chromospheric arc with the objective prism, or by the length of the line on a falling plate. The height reached by any particular line varies at different eclipses, but the greatest heights have been recorded by Mitchell in the eclipse of 1905 ; the height reached by ionized calcium was 14,000 kms. and by hydrogen 10,000 kms.

It had long been a difficulty to explain how chromospheric gases could be supported to such great heights against gravitational forces. If the supporting force were gas pressure the density of hydrogen at a height of 10,000 kms. would be 10^{-25} times that at the base, less than one atom per c.c., and above this height there would not be one atom of calcium per sq. cm. Indeed the thickness of a chromosphere which could be supported by gas pressure would not exceed 100 kms. Consequently it is evident that gas pressure is totally inadequate to explain the great heights recorded in eclipses.

The effectiveness of selective radiation pressure was first suggested by Saha. Milne has shown that the selective radiation pressure can be calculated in the case of ionized calcium and was adequate to support a calcium chromosphere. Milne's theory briefly is as follows. When an atom absorbs a quantum of radiation, the average upwards momentum communicated to it is $\frac{1}{2}h\nu/c$, and the atom will be driven upwards. By the absorption of other quanta, more atoms will be driven upwards and will partly screen the first atom from the full force of the photospheric radiation. This process will continue until the atoms at the top have been so much screened that the radiation pressure just counterbalances the force of gravity. There are three conditions which must be fulfilled for selective radiation pressure to be effective in supporting a chromosphere: (1) the line absorbed by the unexcited atom must be in the visible region where the sun is radiating strongly, (2) the life of the atom in the excited state must not be too long or the atom will fall before it can absorb another quantum, and (3) atomic

collisions must be infrequent. Milne has shown that on account of the simplicity of the atomic states which have to be considered, the case of ionized calcium lends itself to exact calculation. Milne has calculated the density law for ionized calcium supported by radiation pressure and finds that the density is inversely proportional to the square of the height above some fixed level. The density at a height of 8,000 kms. would be one-third of that at the base, and at a height of 15,000 kms. would still be only $\frac{1}{87}$ of the density at the base. Milne therefore finds that the selective radiation pressure theory is adequate to explain the great heights reached by calcium in the chromosphere.

The theory may also explain the formation of prominences by the increased thickness of the chromosphere due to increased local radiation from the photosphere below the prominence. Further, as first pointed out by Sur, the eruptive prominences which are occasionally observed may be explained by the intensified radiation from below being sufficient to overcome the gravitational attraction so that the calcium atoms are driven away from the sun. Milne has shown that a small velocity of ascent would, by a Doppler shift of the absorption towards the violet, increase the background of radiation to which the atoms in the chromosphere are exposed, resulting in an ever-increasing upward velocity of the calcium atoms until they were exposed to the full force of the photospheric radiation outside the calcium lines.

Milne's theory is very attractive, and is in fact the only theory which can in any way adequately explain the observed phenomena even to a limited extent. Nevertheless Milne's theory fails completely in certain respects. The main difficulty is the question of the existence in the chromosphere of other elements than ionized calcium. The theory, as it has been so far developed, can offer no explanation for the normal presence of hydrogen and helium in the chromosphere and in prominences. Let us examine the case for radiation pressure on hydrogen, for example. The unexcited H atom absorbs light of wavelength 1216A, a region in which the sun's photospheric radiation is very feeble. The number of H atoms which can be supported is therefore small, and of this number only a minute fraction can be in a state to absorb the Balmer lines which are the only lines falling within the region where the sun is radiating strongly. Similar, but still stronger, reasons apply in the case of atoms of helium. The radiation pressure theory therefore fails completely to explain the normal presence of H and He at great heights in the chromosphere. The failure is also complete in the case of prominences. The evidence is clear that hydrogen extends in prominences to the same height as calcium. Not only at Kodaikanal, but at Mt. Wilson also, prominences have been regularly photographed in the light of both hydrogen and

calcium. All observers have come to the conclusion that prominences are, essentially, of identical appearance in both hydrogen and calcium. The same is probably true of helium, as can be seen from eclipse photographs. Even when we study eruptive prominences, where the calcium prominence is ascending above the sun's surface with enormous velocities, the evidence, so far as it goes, shows that the height, size, shape and consequently motion, is identical for both hydrogen and calcium. So it would appear that the force lifting up the prominence must be identical on both hydrogen atoms (in the 2 quantum state) and on ionized calcium. It is almost inconceivable that the radiation pressure on two different elements, especially on two whose absorption lines are produced in very dissimilar ways, can be so nearly identical as to show no separation of the two elements in prominences. When we add that the same must apply to a third element, helium, also we begin to appreciate the real difficulties in the way of the radiation pressure theory.

These considerations led me to search for the existence of another element in chromosphere whose presence, if demonstrated, would be a further obstacle in the way of the radiation pressure theory, albeit an obstacle of the same nature as that just considered. Modern atomic theories have enabled progress to be made in interpreting the intensities of spectrum lines in terms of the number of atoms of the element concerned. The first steps in representing the proportion of the different atoms which are present in the sun have been made by Russell. The number of atoms of the metallic elements present in the sun can be stated with some precision, but the data for some of the non-metals are subject to considerable uncertainty. In spite of this, Russell has made an estimate of the composition of the sun. He finds that hydrogen is the most abundant element in the sun, helium and oxygen next, and the metals a long way behind. His figures are hydrogen 92 per cent by volume, helium 3 per cent, oxygen 3 per cent, all metals $1\frac{1}{2}$ per cent to which calcium (both ionized and neutral) contributes $\frac{1}{17}$ per cent. Far more abundant then than calcium are hydrogen, helium, and oxygen. The first two are present in the chromosphere, so why not oxygen also? Oxygen is represented in the sun by only five lines in the infra red, of which the most accessible is the triplet at 7771, 7772, and 7775A. Since photographic plates which are sensitive to infra red light are available in the market it should be possible to test for the presence of oxygen in the chromosphere without waiting for a total eclipse of the sun. The results obtained have been published in Kodaikanal Observatory Bulletin No. 107. It was found that oxygen is a normal constituent of the sun's chromosphere, and that since the infra red triplet is produced by the excited atom of oxygen, the number of unexcited atoms present in the chromosphere

must be large. Again, since the absorption by the unexcited O atoms lies far in the ultra-violet the force exerted by radiation pressure must be infinitesimal.

There is also evidence that Milne's original estimate of the weight of ionized calcium which can be supported by radiation pressure has been grossly over-estimated, since the width of the absorption line which is available for supporting by radiation pressure is much less than originally supposed.

Notwithstanding the beauty and simplicity of Milne's theory, it must be realized that there are grave obstacles still to be overcome. An attempt has been made to invoke the idea of turbulence to explain how the support exerted on calcium is communicated to other elements. The idea seems to be based on a misconception of turbulence. It is impossible to conceive of turbulence in a region where atomic collisions are infrequent. The mean free paths in the chromosphere are so long that the interval between collisions must be reckoned in minutes, if not in hours. Since collisions rarely occur there can be no turbulence, in the ordinary sense, tending to mix atoms of different kinds.

Electrical forces have also been considered and rejected, principally because these forces could only operate on ionized atoms and not on neutral hydrogen or helium.

Considering the fact that calcium only contributes a small proportion to the composition of the sun, and yet does actually reach to heights in the chromosphere greater than those which are far more abundant, it would seem that the rôle of selective radiation pressure on ionized calcium is not by any means a negligible one. Alone of the more abundant elements in the sun is ionized calcium subjected to any reasonable radiation pressure, and it is precisely this element which attains heights as great as, and even greater than, any other. Consequently it would seem that the unknown force which supports the chromosphere begins to operate at a height above that reached by the most abundant metals in the sun, but finds at this height a disproportionate quantity of ionized calcium which has been raised there by virtue of radiation pressure. In this unsatisfactory state we leave the problem, hoping that a way will be found of adapting Milne's theory, which is of singular simplicity and beauty, to account for the facts which at present it fails to explain.

MICROPHOTOMETRY OF FRAUNHOFER LINES.

New ideas of the method of formation of absorption lines have led to the necessity for much work on measuring the intensity of light within absorption lines. It is necessary to obtain not only the distribution of light within the absorption line, but also the total amount of light absorbed in the line.

At Kodaikanal we have recently turned our attention to the microphotometry of some of the stronger lines in the sun's spectrum, principally the lines of calcium and of hydrogen.

Nearly all attempts to measure intensities in spectrum lines depend on first obtaining a photograph of the spectrum, and then interpreting the varying densities in the plate in terms of intensity. In this interpretation, the peculiar properties of photographic plates are involved. The densities in a negative are, for a considerable range, proportional to the logarithm of the intensities of the light falling on the plate. The factor of proportionality for any particular plate is dependent on the developer used and the time of development. But it is known that even within the region of proportionality of density to the logarithm of intensity, the density also depends on other factors, such as the wavelength of the light and on whether the exposure is intermittent or continuous. It is also known that the so-called reciprocity law fails, namely that equal values of the product of exposure time and intensity do not yield equal densities.

These peculiar properties of photographic plates necessitate the adoption of certain precautions in obtaining photographs for photometry. In order to eliminate the effects of properties which are difficult to determine exactly, and which vary from plate to plate, there is only one property which can safely be trusted, namely that equal intensities from two sources emitting the same wavelength will give equal densities on the same photographic plate when the conditions of exposure and development are identical. If the durations of exposure are not the same, some allowance which cannot be determined very exactly has to be made, and if the wavelengths are not the same, we have in some way to make allowance for the varying behaviour of the plate with wavelength. The only safe procedure for calibrating the intensities in a photograph is to give the same exposure on the same plate to a standard source emitting the same wavelength. Even then special precautions have to be taken in the development of the plate, for Eberhard has found that there is local exhaustion of the activity of a developer in those regions of the plate where the density is greatest. One way of minimizing the Eberhard effect is to develop with a brush which sweeps out of the emulsion the byproducts of the developer retarding development of the well-exposed parts of the emulsion.

So with every spectrum plate which has to be photometered it is necessary to imprint on the same plate and with the same exposure, other standardizing spectra in which the intensities have been varied in some known manner to cover the range of intensities which are to be measured. The most usual way of varying the intensity in the standardizing spectra is by the use of an absorption wedge across the spectrum, either a wedge which produces a gradual weakening, or a step wedge which

weakens the intensity in the standardizing spectrum by known steps. The calibration of the wedge employed calls for some care. It is not very difficult to measure the opacity of the different steps of a step wedge but it is necessary to take into account the fact that the opacity depends on the way in which the wedge is used. The opacity of a wedge placed in a beam of parallel light is different from the values obtained in non-parallel light by an amount which depends partly on the graininess of the absorbing medium of which the wedge is constructed. At Kodaikanal we have used step wedges made from photographic plates as being very convenient in use, but it has been found, for example, that the opacities of the same wedge are vastly different when the wedge is used in front of the spectrograph slit from those when the wedge is used immediately in front of the photographic plate. It is of primary importance, therefore, that the opacities of the wedge should be determined in the position in which the wedge is to be used. This has been done at Kodaikanal in two ways, the first by interposing perforated screens in the optical path and the second by comparing the densities given by the step wedge with those produced by a standard wedge used in the manner for which it was standardized. The wedge steps must be determined over a range of wavelengths in which it is to be used, for most wedge opacities vary slightly with wavelength.

The problem of spectro-photometry is now reduced to one of measuring the densities in different parts of the spectrum plate. Various types of photometers are available in the market for density measurements. The most common forms of photometer measure the amount of light passing through the plate from a steady lamp on to a thermocouple or a photoelectric cell. For spectrum measures it is necessary that the light should pass through a very narrow slit parallel to the spectrum lines in order to obtain a sufficiently high resolving power. At Kodaikanal we have used the Cambridge Instrument Company's microphotometer which employs a photoelectric cell, the varying current passing through the cell being recorded on bromide paper by the shadow of an electrometer. This instrument has proved very reliable in practice, for it is found to have a steady zero and to give the same deflection under the same conditions when proper precautions are taken.

Let us now consider briefly the formation of an absorption line by an absorbing atmosphere such as we have in the sun's reversing layer. It has been pointed out by more than one investigator that the term 'absorption' line is really a misnomer. True absorption means the process whereby an atom, having reached an excited state by the absorption of a quantum of light of appropriate wavelength, returns to its former state by a super-elastic collision with another atom without the emission of light, but with an increase in the kinetic energy

of the atoms. True absorption is the exact reverse of emission by thermal excitation. In thermal emission atomic collisions raise the atom to an excited stage at the expense of the kinetic energy of translation. What is commonly termed an 'absorption' line is rather believed to be caused by the scattering of light from the photosphere by the atoms present in the atmosphere. In scattering, a quantum of light of suitable wavelength is absorbed by an atom which returns to its former state by re-emitting a quantum of the same wavelength in all directions. An 'absorption' line is formed in the light emerging through the scattering atmosphere because only a portion of the light scattered is re-emitted in an outward direction.

We must now consider what are the causes which make absorption lines have appreciable width. We need consider, in the sun's absorbing atmospheres, only three causes of broadening: First, the Doppler broadening due to the movements of the absorbing atoms; second, the Stark effect or broadening due to inter-atomic electrical fields which probably includes the broadening due to pressure; and third, abundance broadening. This latter is of special importance. A formula for the abundance scattering coefficient was given by Voigt and was first applied by Unsold to determine the numbers of atoms in the sun's reversing layer. This abundance scattering coefficient is given by

$$\sigma = \frac{2\pi e^2}{3m^2c^4} \cdot \frac{\lambda_0^2}{(\lambda-\lambda_0)^2} \cdot Nf$$

where σ = the scattering per cm. length,
λ_0 = wavelength at the centre of the absorption line,
N = number of absorbing atoms per c.c.,
f = oscillator strength for this particular line,

and the remaining terms have their usual significance.

Now it has not yet been found possible to give an exact expression for the contour of an 'absorption' line produced by scattering in an atmosphere of finite thickness. The best which can be done at present is to use approximations made under simplifying assumptions. Schuster showed that if we assume a definite photospheric surface underneath a homogenous scattering atmosphere, the contour of the resulting 'absorption' line will be given by

$$r = \frac{1}{1+\sigma H}$$

where r = ratio of intensity in the line to the intensity of the photospheric radiation,
σ = scattering coefficient of the atmosphere,
and H = the height of the atmosphere.

The number of scattering atoms in an atmosphere can be most conveniently deduced by measuring the total amount

of energy 'absorbed' from the photospheric background. This is called the equivalent width of the line, and is expressed as the wavelength range of the continuous spectrum which is absorbed in the whole width of the line; i.e. an equivalent width of 1A means that the absorption line prevents the energy included in 1A of the continuous spectrum from passing through the atmosphere. The equivalent width of a line is therefore measured by $\int_{-\infty}^{\infty} (1-r)d\Delta$, where $\Delta = \lambda - \lambda_0$. In the case of abundance scattering and using Schuster's approximation, Unsold showed that the equivalent width (W) of a line is proportional to the square root of the number of scattering atoms above unit area of the photosphere, namely

$$W = \frac{\pi e^2}{mc^2} \cdot \lambda_0 \cdot \sqrt{\frac{2\pi}{3}} \cdot \sqrt{NfH}.$$

When however the width of a line is controlled by collision scattering, the scattering coefficient follows an entirely different law and the corresponding equivalent width is then given by

$$W = \frac{\pi e^2}{mc^2} \cdot \lambda_0{}^2 \cdot NfH.$$

In the case of an actual solar atmosphere where both kinds of scattering are operating simultaneously, the first formula will give an upper limit to the number of scattering atoms, and the second a lower limit.

Let us pause a moment to consider the conditions for the centre of the absorption line. Here the collision damping has least effect and only the radiation damping is effective. We can consequently use the scattering coefficient given above. It is seen that, according to the formula, the scattering coefficient for the centre of the line $(\lambda - \lambda_0) = 0$ becomes infinite and the absorption of the photospheric radiation should be complete, i.e. $r=0$. Now it is well known that the central intensity of even the most intense of the Fraunhofer lines is not zero, in fact spectroheliograms are obtained daily with the light in the centre of Fraunhofer lines, and in them we see the familiar features due to varying intensities in the centre of the line at different parts of the sun's surface. Some attempts have been made by Woolley and Strömgren to explain the appreciable central intensities which are found in the Fraunhofer lines but their postulates have not yet been sufficiently tested.

The estimates of the numbers of atoms in the sun's reversing layer have been first made by Unsold, and his results are well known. At Kodaikanal we have been engaged in measuring

the changes in the contours of absorption lines as we pass from the centre of the sun's disc to the limb. At the sun's limb we are looking through the sun's atmosphere at an angle inclined to the sun's radius. As we pass from the centre of the disc to the limb, the number of atoms in the path of the photospheric radiation would be expected steadily to increase, and consequently the widths of all lines should steadily increase. This is however not what is actually observed and the discrepancy cannot be ascribed to the deficiencies of the Unsold theories of scattering. Let us look, for instance, at those absorption lines in the sun's spectrum which are produced by the earth's atmosphere. Examples of these are the A and B bands in the sun's spectrum. When the sun is low in the sky these lines are considerably broadened compared to when the sun is high. In fact, they form a very valuable confirmation of Unsold's law for abundance scattering. Since the temperatures in the earth's atmosphere are comparatively low, the Doppler effects are small and the conditions may therefore be taken to be those of pure abundance scattering, for which Unsold's law should strictly hold. From photographs taken at Kodaikanal we have confirmed results obtained elsewhere that the equivalent width of the B band in the solar spectrum increases proportionately to the square root of the length of path of the sun's rays through the earth's atmosphere, i.e., proportional to $\sqrt{N}$ exactly as required by Unsold's law.

When however we turn to the sun, we find that the width of the absorption lines actually diminishes as we approach the limb of the sun, which is entirely opposed to what one might have expected. It is the consideration of the cause of this which has led us to new conclusions regarding the number of atoms in the sun's reversing layer, and particularly to the lower portions of that layer. Whatever may be the theory of formation of absorption lines which we prefer to adopt, the evidence of the sun's spectrum leads to the conclusion that the number of atoms down to the depths to which we can see is greatest for the centre of the disc. Notwithstanding the fact that at the limb the line of sight is more inclined to the sun's radius, the depth down to which we can see at the limb contains fewer atoms than when we look at the centre of the disc. The cause for this reduction in the number of absorbing atoms is ultimately the same as the cause of the darkening of the sun's limb in white light. The limb of the sun is less bright than the centre of the disc, and it is commonly accepted that the cause of the darkening at the limb is the fact that there we reach complete opacity at a higher level than when we look at the centre of the sun, on account of the greater inclination of the line of sight at the limb. The greater length of the inclined line of sight at the limb prevents us from seeing so deeply into the sun. Consequently at the limb we see the continuous

spectrum radiation from a layer which is not so deep as, and therefore cooler than, the layer to which we see at the centre of the sun's disc. So that when we are measuring an absorption line at the sun's limb, we are measuring the number of atoms above a higher layer than when we measure at the centre of the disc, albeit along a more inclined path. We have therefore two opposing tendencies at the limb of the sun; the longer path due to the more inclined line of sight tends to increase the width of the spectrum lines, and the shorter depth to which we can see down into the sun's atmosphere decreases the width. The evidence shows that the latter tendency predominates. We can allow for the increase in the path through the atmosphere from geometrical considerations, but we still have to estimate the depth into the sun's atmosphere to which we can see at different parts of the sun's disc. The simplest way to estimate this seems to be from the temperature gradient in the sun. Eddington has given formulæ for the temperature gradients which should apply to that part of the atmosphere which we are now considering. Essentially it comes to the same thing as the temperature gradient which will explain the darkening of the sun's limb in white light. From these values we have deduced, by means of the measurements made at Kodaikanal, estimates of the densities of calcium and of hydrogen in the lower parts of the sun's reversing layer. These results are :—

neutral calcium ..	..	$7{\cdot}8 \times 10^{10}$ atoms per c.c.
ionized calcium ..	..	$2{\cdot}1 \times 10^{13}$ atoms per c.c.
hydrogen (2 quantum)	..	$3{\cdot}4 \times 10^{10}$ atoms per c.c.

From these values we can deduce their partial pressures and that of electrons. The data apply to the lowest parts of the reversing layer.

In this way we have applied the principle that the equivalent widths of absorption lines are a measure of the number of atoms in the solar atmosphere, and have deduced the physical conditions obtaining in the lowest parts of the reversing layer. The interpretation of photometric measures still requires the solution of several problems relating to atomic theory, namely the problem of the appreciable intensity at the centre of absorption lines, the problem of radiation passing through an atmosphere of finite thickness, the problem of the discrepancy between observed contours of absorption lines and theory, and also the problem of the great intensity of the Balmer lines.

Section of Mathematics and Physics.

Abstracts.

1. The milky way in the constellations lyra and cygnus.

T. P. BHASKARA SHASTRI, Hyderabad.

A considerable part of the milky way in lyra and cygnus lies in the 'Cart du ceil' zones $+36°$ to $+39°$ which have been recently photographed at the Nizamiah observatory, Hyderabad. One of the most interesting portions of the galaxy occurs in cygnus where it is bright and broad and divides into two great streams containing much nebulous matter, luminous as well as dark. Photographic magnitudes have been derived for the faint stars down to the thirteenth magnitude from the measured diameters of the star images in the Hyderabad series of photographs, and counts of stars of different brightness have been made in these regions and arranged according to their photographic magnitudes. For stars up to magnitude 11·5 in this area the spectral types are given in the catalogue of Henry Draper Extension. The available data have been analyzed in detail and discussed in connection with the study of the structure of the extensive star clouds that are found in these parts of the milky way.

2. Equilibrium of the solar chromosphere.

C. P. S. MENON, Kodaikanal.

Theories of the equilibrium of the solar chromosphere are not entirely satisfactory. Milne's theory of monochromatic radiative equilibrium successfully explained the formation of the Ca^+ chromosphere, but failed in the case of atoms like hydrogen. The latest theory, due to Chandrasekhar, sought to provide a hydrodynamical solution of the problem by assuming a radiating surface (located at the base of the chromosphere) which varies periodically about a mean flux just enough to support the atoms above. This cannot explain the hydrogen chromosphere or prominences. His solution of the differential equations is incorrect: under the conditions of periodicity assumed, it is only one of a family of solutions, determined by the initial conditions. Because of this, and because of his conditions strictly confining the atoms to the limits of the chromosphere, the trajectories and the boundary of the chromosphere rise up into crests above the points of minimum repulsion of the radiating surface, and dip into troughs above points of maximum repulsion. It is impossible to explain the equilibrium of such a self-contained chromosphere by means of radiation-pressure; the diminution of intensity vertically outward from the base of the reversing layer, and an exchange of atoms between the two layers will have to provide the solution.

3. The number of calcium atoms in the sun's reversing layer.

T. ROYDS *and* A. L. NARAYAN, Kodaikanal.

Microphotometric measures have been made of the contours of the lines of neutral and ionised calcium in the sun's spectrum at different parts of the sun's disc. From the equivalent widths of these lines, the number of atoms above 1 sq. cm., of the sun's surface has been worked out. By making use of the known law of darkening across the sun's

disc, it has been found possible to deduce the number of atoms per c.c. in the sun's reversing layer. Preliminary average values are as follows :—

Neutral calcium $7{\cdot}8 \times 10^{10}$ atoms per c.c.
Ionized calcium $2{\cdot}1 \times 10^{13}$ atoms per c.c.

Saha's ionization formula enables the electron pressure in the reversing layer to be calculated.

4. The number of hydrogen atoms in the sun's reversing layer.

T. ROYDS, Kodaikanal.

Microphotometry of the Balmer series in the sun's spectrum has given the equivalent widths for different points on the sun's disc, from which the number of hydrogen atoms in the 2-quantum state can be calculated. As is well known, the results for the different lines are not consistent, probably on account of the effects of collision-damping on the higher members of the series. Using the known law of darkening across the sun's disc, the number of atoms per c.c. has been found from the H_α line to be $3{\cdot}4 \times 10^{10}$. This is the number of atoms in the 2-quantum state. It is known that the ratio of atoms in the 1-quantum state is less than the ratio corresponding to thermodynamic equilibrium.

5. Hyperfine structure of spectrum lines of manganese in the ultra-violet region.

WALI MOHAMMAD, Lucknow.

The hyperfine structure of manganese lines in the visible region has been communicated in a previous paper. An arc is produced in vacuum by means of a coated cathode and a manganese anode. The lines so emitted are observed by means of a Hilger 3 metre spectrograph combined with two large size Lummer Quartz Plates. The hyperfine structure of 35 lines has been examined. Out of these, only 10 show definite structure, the remainder appears to be simple.

6. Structure of ionised bromine (Br. III).

K. R. RAO, Waltair.

By a study of the discharge through bromine and of vacuum sparks between electrodes tipped with different bromides, the spectrum of bromine in the various states of ionization of the atom has been investigated. The investigation has revealed that the characteristic energy states of Br. III have lines different from those suggested by Deb. The new scheme proposed by the author is in consonance with the corresponding spectra of As I and Se II analyzed previously (K. R. Rao, *Proc. Roy. Soc.*, 1930 and 1934).

7. Extension of Se II spectrum.

K. R. RAO, Waltair.

In a previous communication (cf. *Proc. Roy. Soc.*, 1934 and *Proc. Ind. Sc. Cong.*, 1934) the analysis of Se II was presented, consisting mainly of the deepest terms $4p\ ^4S$, ^2D, ^2P, and $5s\ ^4P$, ^2P, and others of the $5p$ electron state. The present extension deals with the terms of sp^4 inner electron transitions and doublets depending on the ^1D state of the parent ion.

8. On some characteristics of the long and short spectral lines of silver, zinc and iron.

S. DATTA *and* K. N. CHATTERJEE, Calcutta.

If an image of the arc in the transverse position is thrown on the slit of a spectrograph, so that the spectrum obtained is that of a section of the arc normal to its length, then some lines are seen to stretch right across the core from side to side, while others seem to originate from the core alone and thus appear to have a length much shorter than the former. Lockyer designated them as *long* and *short* lines. In a previous paper (*Ind. Jour. Phy.*, Vol. IX, part IV, 1935), it has been shown that if for each spectral line the relative orientation of the resultant l and s vectors be calculated for the initial and final states, by the usual formula, then in general, those lines are short for which the change in the orientation is large or there is change in the multiplicity, whereas those for which the orientation change is small come to the category of long lines.

The work has now been extended to silver, zinc and iron and the same generalizations arrived at. In the iron arc there is hardly anything like a flame of the arc so that in the open arc all the lines have nearly the same length and the classification of the long and short lines becomes rather difficult. With the arc at reduced pressures, however, this difficulty is obviated, as it is found that short lines further shorten in length, whereas the long lines persist as long lines even with reduction in pressure.

9. Scattering of light by undercooled liquids.

J. C. KAMESVAR RAV *and* V. DAKSHINA MURTI, Hyderabad.

The scattering of light by two undercooled liquids, phenol and bezophenone, was studied for temperatures higher and lower than the melting points. It was found that the intensity of light scattered transversely decreases with temperature till the melting point, below which it increases again. The depolarization factor, however, regularly decreases with increasing temperature. These results are in agreement with the theory of Einstein and Smoluchowski, as modified by Cabannes and Raman. These results show that there is a clustering of molecules below the melting point. This view is further confirmed by the study of the depolarization of the scattered light, when the incident light is plane polarized with the electric vecto · horizontal and vertical.

10. Atomic positions in acenaphthene.

K. BANERJEE *and* K. L. SINHA, Dacca.

The space-group of acenaphthene has been found to be $D_{2h}p\gamma\mu\mu$ the axial lengths being $a=8{\cdot}32$Å, $b=14{\cdot}15$Å, $c=7{\cdot}26$Å with four molecules per unit cell. Intensities of reflections from more than 250 planes have been estimated and it has been found that the two-fold axis of the acenaphthene molecule lies along the b axis, and the plane of the molecule makes an angle of 23° with the c face. The aliphatic carbon atoms are mutually at a distance of 1·55Å, while the aliphatic to aromatic carbon distance is 1·48Å, and these bonds are inclined to the two-fold axis, and make an angle with the aliphatic bond which is not much different from the tetrahedral angle.

11. Structure of benzil.

K. BANERJEE *and* K. L. SINHA, Dacca.

Benzil belongs to the rhombohedral trapezohedral class. From rotation photographs about different axes it has been found that the

basic lattice is hexagonal with axial lengths $a = 8{\cdot}38$Å and $c = 13{\cdot}71$Å, and three molecules per unit cell; and from oscillation photographs the space-group is found to be D_3c 31 and D_3c $\bar{3}1$, for the two enantiomorphic forms. The intensities of reflections from the same planes were measured from powder photograph, and atomic positions were determined by the trial and error method. The two benzene rings are found to lie on parallel planes and the two aliphatic carbons to lie on a plane normal to the benzene rings.

12. The structure of calosterol.

K. Banerjee *and* A. C. Chanda, Dacca.

The new type of sterol extracted by K. P. Basu and M. C. Nath and named by them as calosterol was subjected to goniometric and X-ray measurements. The symmetry was found to be higher than all the other sterols, the crystal belonging to the orthorhombic class with $a = 11{\cdot}27$A, $b = 7{\cdot}90$A and $c = 35{\cdot}3$A. The density was found by the suspension method to be 1·111, so taking 4 as the number of molecules per unit cell the molecular weight is 529 and the molecular formula is $C_{38}H_{57}O$. Detailed crystal structure analysis is in progress.

13. The spectra of SeO and SeO_2.

R. K. Asundi, M. Jan Khan, *and* R. Samuel, Aligarh.

The emission spectrum of SeO and the absorption spectrum of SeO_2 are analyzed. The energy of excitation and the energy of the Se=O bond are almost identical in SeO and SeO_2, and the vibrational frequencies of SeO have almost the same value as the frequencies of the symmetric valence vibration of SeO_2, both in the normal and in the excited state. The same is true about the corresponding anharmonic constants of the two excited molecules; that of excited SeO could not be measured.

These results indicate stro**.**g localization of the two Se=O bonds in SeO_2.

The analysis of the band system of SeO_2 is in complete agreement with Herzberg and Teller's theoretical selection rule for $\Delta v_{antisym.}$ of polyatomic molecules.

14. The band spectrum of germanium oxide.

P. C. Mahanti *and* A. K. Sen Gupta, Calcutta.

A number of bands degraded to the red have been observed in the region $\lambda 2400$–$\lambda 3100$ in an arc between carbon electrodes, the lower one containing metallic germanium. These bands also appear in the spectrum of an uncondensed discharge through germanium chloride vapour, and become intense if oxygen at an optimum pressure is introduced into the discharge tube.

From the vibrational analysis the following constants have been evaluated:

$$\nu_e = 37765 \text{ cm}^{-1}$$
$$\omega'_e = 648$$
$$\omega''_e = 985$$

The presence of isotopic heads and the agreement between their calculated and observed positions definitely proves that their emitter is the germanium oxide molecule.

The fine structure analysis of these bands is in progress.

15. The band spectrum of gallium oxide.

P. C. MAHANTI *and* M. K. SEN, Calcutta.

The spectrum of gallium oxide has been photographed by means of Fuess prism spectrographs of large light gathering power. A band system lying in the region λ3600–λ4300, and consisting of well-developed sequences degraded to the red, has been measured. The bands are very much alike in appearance to the violet CN bands. Their vibration frequencies in the lower and upper states of the band system are not very different from one another.

From high dispersion spectrograms it appears that the band system is probably due to a $^2\Sigma \rightarrow {}^2\Sigma$ transition and is thus analogous to the known band system of aluminium oxide and to the β-bands of boron-monoxide.

16. Rotational analysis of the band spectrum of aluminium oxide.

P. N. GHOSH *and* M. K. SEN, Calcutta.

Aluminium oxide emits a bright band spectrum in the region λ4000–λ6000 and consists of a large number of red-degrading bands included in a single system. Their vibrational analysis was initiated by Mecke in 1925. Later on Pomeroy conducted a fine structure analysis of only the (0, 0), (0, 1) and (1, 0) bands and attributed the system to a $^2\Sigma \rightarrow {}^2\Sigma$ transition. His dispersion was not, however, sufficient to determine the σ-type doubling in the bands.

In the present investigation, using a Fuess glass spectrograph of large light-gathering power, it has been possible to add a number of new bands to the system. This has enabled us to determine the vibrational constants of the molecule more correctly. In addition to the bands analysed by Pomeroy, a few more bands which are relatively intense have been photographed in the first and second orders of the 21-ft. grating. The fine structure analysis of these bands from the new measurements confirms in the main the rotational constants given by the above author for the aluminium oxide molecule. It has also been possible to measure quantitatively the σ-type doubling of the rotational lines of the bands.

17. Rotational structure analysis of the band spectrum of tin oxide.

P. N. GHOSH *and* A. K. SEN GUPTA, Calcutta.

The spectrum of tin oxide consists of well-marked bands degraded to the red, and extends from blue to near ultra-violet. Their vibrational analysis was first carried out by Mahanti and later on confirmed by Connelly and by Loomis and Watson. The latter authors have added a new band system which appears only at reduced pressure.

In the present investigation a fine structure analysis of the strongest bands of Mahanti's A-system has been carried out. For this purpose, photographs have been taken in first and second orders of a 21-ft. concave grating set up on Paschen mounting. Each band consists of two fairly strong series of bands evidently due to *P* and *R* branches of the main molecule $Sn^{120}O$. None of these series shows signs of Λ-type doubling, nor there is any sign of a short *Q*-branch, although a systematic search for the same was made. This means, therefore, that the A-system originates from a $^1\Sigma \leftarrow {}^1\Sigma$ transition.

18. Magnetic birefringence of organic substances in solutions, part II.

L. D. MAHAJAN, Patiala.

The magnetic birefringence of a number of simple benzene, naphthalene, and anthracene derivatives is measured, with the same apparatus as used by Dr. S. W. Chinchalkar (*Ind. Jour. Phys.*, Vol. 7, p. 491, 1933), and some important conclusions regarding the structure of the molecules and its influence on the magnetic and optical anisotropies are drawn by the author.

For most of the benzene derivatives, the gram-molecular birefringence is nearly of the same magnitude as for benzene, suggesting that the bulk of both the magnetic and optical anistropies of the molecule is due to the benzene ring in it. An exception should be made in the case of benzoquinone for which the gram molecule birefringence is nearly 4 times that of the benzene. Dimesityl and diphenyloxide have been studied, and it is found that the two benzene rings in them are nearly coplanar. All the compounds with condensed benzene rings have very high birefringence.

19. Measurement of earth-air electric current.

D. V. KAMAT *and* S. K. BANERJI, Poona.

During 1933–35, an apparatus, similar to that adopted at Kew, was set up at Poona for taking continuous records of earth-air electric current. This consisted of a test plate (90 cm $\times$ 60 cm.), exposed flush with the ground over a pit, and insulated by sulphur insulators. To ensure uniformity and to avoid rapid fluctuations of the electric field, an insulated net with half an inch mesh was spread over the test plate, about 50 cm. above it, and joined to an insulated ion collector placed at the same level. The test plate was joined to one pair of quadrants of a Dolezalek electrometer. The charge acquired by the test plate consists of two parts: (1) due to earth-air current, and, (2) due to earth's field $\left(Q=\frac{1}{4\pi}\frac{\partial V}{\partial n}\right)$. The effect of the charge due to the earth's field on the needle was compensated by joining the ion collector to the opposite pair of quadrants of the electrometer through an adjustable condensor and suitably adjusting the condenser gap. The needle was given a fixed and fairly high potential. Under this condition the charge acquired by the test plate due to earth-air current is proportional to the deflection of the needle. This was recorded photographically every ten minutes by means of a recording cylinder and an automatic earthing device which earthed the test plate for two minutes at the end of every eight minutes. On the same photographic paper the variation of potential gradient was also recorded by means of a second quadrant electrometer.

Continuous records of earth-air current obtained in this way have been analysed for diurnal and other variations. Abnormal variations have been correlated with special meteorological conditions such as thunderstorms, dust in the air, fog, drizzle, heavy shower, etc. The mean value of positive earth-air current is $0{\cdot}65\times10^{-16}$ ampere per sq. cm. For comparative purposes, an alternative method involving the use of a thermionic valve was adopted later for the measurement of earth-air current.

20. Electrical charge produced on liquid drops or solid particles by various mechanical methods.

R. D. GODBOLE *and* S. K. BANERJI, Poona.

Lenard, Thomson, Busse, and others have studied in considerable detail the formation of ions by spraying liquid, by bubbling, breaking

drops into smaller drops, impinging them upon a solid wall, or breaking a continuous jet. While in individual cases the phenomena can be explained on the assumption of an electrical double layer, it is not easy to explain by this method the widely varying charges obtained by subjecting different substances into mechanical processes of these types. For instance, when water is sprayed, the charge in the water drops is found to be 2 or 3 times that in the air, while if turpentine is sprayed most of the charge is found in the turpentine drops and very little in the air. On the other hand, if amyl alcohol is sprayed, most of the charge goes to the air and very little is found in the amyl alcohol drops. A jet of carbon dioxide striking a plate produces many times more charge than a similar jet of water striking the same plate. Accordingly experiments were arranged with very large number of substances to find out the charge in the substances and the surrounding gas when these are subjected to mechanical processes like the above and various others, such as, two jets striking, slipping on an inclined plane, etc. These show that the charge depends on the substances in action, the state of the substances, the intensity of the mechanical processes, the conductivities, and the dielectric properties of the substances, and lead to certain generalization of the laws of cataphoresis.

21. Absorption of solar radiation by ozone in the earth's atmosphere, and its effect on upper air temperatures.

K. R. RAMANATHAN, Poona.

Assuming that the sun radiates as a black body at 6000°K. and that the vertical distribution in the earth's atmosphere of ozone is as obtained by Dr. F. W. P. Gotz, Meetham and Dobson in Europe, the amounts of solar energy absorbed at different heights up to 50 kms. in the earth's atmosphere are calculated from the absorptivities of ozone in the ultra-violet for different zenith distances of the sun. It is found that the curve showing the amount of energy absorbed by unit mass of the atmosphere against height shows great similarity with the height-temperature curves obtained by Duckert and Whipple by sound-ranging experiments in Europe. It is shown that the out-radiation of energy by ozone itself through its infra-red bands can contribute but little to the loss of energy in these regions, and that the main loss must occur by the intermixed water-vapour as assumed by Gowan.

The reflection of sound from the upper atmosphere observed by German workers during the winter of the last polar year, when the upper atmosphere could not have been illuminated by sun's rays from over three weeks, remains unexplained.

22. The rôle of the soil in controlling the diurnal variation of moisture in the air layers near the ground.

L. A. RAMDAS, Poona.

Investigations carried out at the Central Agricultural Meteorological Observatory at Poona during the last three clear seasons show that the upper layers of the soil play an important part in controlling the distribution of moisture with height in the air layers near the ground. It is observed that the diurnal variation of the absolute humidity is largest near the ground and decreases rapidly with height. It is also seen that in spite of this disturbing influence of the ground the vapour pressure is the least variable property of the air layers near the ground so long as the sample of air remains the same.

23. Variation of rainfall with lunar periods in Calcutta for the month of July.

P. C. MAHALANOBIS, Calcutta.

Records of rainfall during the period 1878–1924 over one complete lunar period in the month of July have been analyzed for determining variation, if any, of rainfall with these lunar phases (i.e. tithis). The analysis shows that the difference was not appreciable either in the new moon period or in the full moon period. There is however a significantly higher rainfall in the new moon fortnight—the difference being 0·1169 inch per day over the full moon period. The data also show that the average rainfall during July was practically steady over the whole period of 47 years of the present investigation.

24. A seismometric study of the Baluchistan earthquake of May 31, 1935.

S. C. ROY, Bombay.

This paper gives an account of a preliminary analysis of the seismograms of the Baluchistan Earthquake received on loan from about a hundred seismological stations. The results of the analysis are set out in a series of time-distance curves of the identifiable phases, and special features of the curves are discussed.

25. Direct determination of the electrical constants of soil at radio-frequency.

B. SEN GUPTA *and* S. R. KHASTGIR, Dacca.

The electrical conductivity σ and the dielectric constant ϵ of three different specimens of Dacca soil were directly determined by a resonance method for various values of moisture content from 0 to 40% and for varying frequencies from $\cdot 135 \times 10^6$ to $2\cdot 72 \times 10^6$ cycles/sec. The values of σ and ϵ for the specimen of soil taken from a depth of 15 feet were decidedly lower than those for the surface soil. Both σ and ϵ were found to increase with the moisture content, each tending towards a constant value for large values of the moisture content. The variation of σ and ϵ with frequency was also considerable.

Smith-Rose's direct determinations of σ and ϵ with specimens of English soil gave distinctly larger values, whereas Ratcliffe and White's values were of the same order as those obtained by us.

It should be mentioned that the values of the electrical constants of the soil obtained by direct experiments agreed in their order of magnitude with the values deduced from the attenuation measurements.

26. Analysis of signal-fading observations.

B. SEN GUPTA *and* S. R. KHASTGIR, Dacca.

An analysis of 58 sets of continuous observations of 'fading' of the Calcutta V.U.C. signal ($\lambda = 370\cdot 4$m.) received at Dacca is given in the paper. The principal causes of signal variations are the random changes in phase and amplitude of the downcoming wave returned from the ionosphere. The analysis shows that the fading of the signal can be regarded, partly at any rate, as an effect of interference between the ground wave and the downcoming wave with constant amplitudes and random phase-difference. Evidence of such 'phase'-fading has been statistically shown. No similar evidence for 'intensity'-fading has been obtained, although such intensity-changes may be responsible in a large measure for the fading of the signals.

It has been possible also to estimate from this analysis the value of the ratio of the vertical electrical forces produced by the downcoming wave and the ground wave. Between Calcutta and Dacca, the ratio has been shown to have a value lying between 2 and 3.

27. Ionospheric height measurements in Eastern Bengal by the method of signal-fading.

S. R. KHASTGIR, B. SEN GUPTA, *and* DEBNARAIN CHAUDHURY, Dacca.

1. Experiments are described where simultaneous observations were taken at short intervals of the intensities of fading of the Calcutta signal (V.U.C. $\lambda=370{\cdot}4$m.) received at Dacca on a loop and on a vertical wire aerial. Two similar receiving sets of high amplification provided with two similar mirror galvanometers in their respective detector circuits with a Wheatstone Bridge arrangement for balancing the no-signal current were employed. The distance between Dacca and Calcutta is 240 km.

2. The theory of a modified form of Appleton and Barnett's method of measuring the angle of incidence of the atmospheric waves, coming down after reflection from the upper atmosphere, has been described. The method has been applied to the determination of the effective height of the E-layer. The method claims simplicity in experimental technique.

3. Evidence has been obtained of multiple reflections at the E-layer. The receptions of the E_1, E_2, E_3, and E_4 rays have been recorded. On one occasion, there was an indication of the E_6 ray. The average height of the E-layer has been found to be 106 km.

4. In some cases the height has been found to be distinctly greater,—the mean of such values being 137 km. This corresponds to the E-layer. The results indicate that the E-layer wanders between these limits.

5. There have been strong indications of occasional penetration of the E-layer, by the 370m. waves and of simultaneous receptions of the E_1- and F_1-rays on certain occasions, indicating that the electron-density of the E-layer has been on these occasions greater than 3×10^3 and less than 6×10^3 electrons/cm.^{3} during the hours of observations (7-30 P.M. to 10-30 P.M.). This occasional 'patchy' nature of the E-layer has been previously reported by Appleton in England and also by Martyn, Cherry, and Green in Australia. The average height of the F-layer has been found to be 215 km.

6. A discussion has been given of the uncertain factors in the experimental conditions.

28. Inter-electrode resistance of a triode valve at high frequencies.

P. DUTT *and* S. S. BANERJEE, Benares.

During recent years a large number of experiments have been carried out by various investigators to measure the dielectric constant of an ionized gas containing either ions and electrons both or of a purely electronic atmosphere, in order to verify the Eccles-Larmor theory. But comparatively little has been done on the measurement of conductivity or resistance of such a medium, and specially its variation with frequencies. Notable contributions in this direction have been made by L. Hartshorn (*Experimental Wireless and Wireless Engineer*, 8, 413, 1931) and S. K. Mitra and B. C. Sil (*Phil. Mag.*, 13, 1081, 1932).

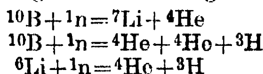
In the present investigation, the inter-electrode resistance of triode valves for plate, grid space has been determined for frequencies ranging from 1000 cycles per second to $1{\cdot}4\times10^6$ cycles per sec. Miller's method has been adopted for the audible frequencies and the distuning method

at higher frequencies. Variation of the resistance has also been studied for different anode and grid potentials. The resistance is found to increase considerably with frequency. The effect of space charge in increasing the resistance is recorded. A number of curves have been drawn showing the changes of resistance with frequencies, grid and anode potentials, and filament current. Explanations have been given for each case.

29. The disintegration of boron and lithium by neutrons.

H. J. TAYLOR, Bombay.

When boron and lithium are bombarded by slow neutrons, disintegration takes place according to the following schemes :—



$$^{10}B + {}^{1}n = {}^{7}Li + {}^{4}He$$
$$^{10}B + {}^{1}n = {}^{4}He + {}^{4}He + {}^{3}H$$
$$^{6}Li + {}^{1}n = {}^{4}He + {}^{3}H$$

These reactions have been studied by means of a technique which has recently been worked out, whereby the tracks of the resulting particles are recorded directly in a photographic emulsion, and then examined under a high magnification. The energy released in each reaction has been worked out, and is shown in each case to be in accordance with the value which may be deduced from the known masses of the nuclei involved. Photomicrographs of the tracks of the particles are given.

30. The radioactivity of samarium.

H. J. TAYLOR, Bombay.

The photographic technique has been applied to study the radioactivity of samarium. The existence of the short-range α-particles, which had been reported previously, has been confirmed. From the measurements of the tracks an accurate value of the range of these α-particles has been deduced.

Tracks have also been found corresponding to particles of about 3·5 cm. range. These particles are much less frequent than the short-range (1·1 cm.) α-particles. The evidence is very strong that these longer tracks correspond to singly-charged particles, and not to α-particles. We have here therefore the first case of a radioactive body which spontaneously emits H-nuclei.

31. Ring phenomena in positive ray bombardment on glass.

B. DASANNACHARYA, V. T. CHIPLONKAR, *and* L. G. SAPRE, Benares.

Positive rays of hydrogen of discharge voltage about 20,000 fell on a glass plate kept perpendicular to the beam at a distance of 11 cm. behind the front face of the cathode. After an exposure of some hours a brown deposit was seen on the glass plate. On examination in transmitted light the deposit showed three brown rings of diameters 8, 16, and about 27 mm. in diameter. The first and second rings had a thickness of 0·5 mm. They are not interference fringes and hence their peculiar interest.

32. Ring deposits in positive ray bombardment under steady voltage.

B. DASANNACHARYA *and* G. SIVASANKARA RAO, Benares.

The phenomenon was investigated by interposing plates of glass at a definite distance behind the cathode, namely 6 cm., and the positive rays of one well-defined voltage was used, namely 7 cms. of cathode fall. Sharp rings were obtained with times of exposure varying from 1 to 20 hours. The progressive changes in the nature of the rings have been carefully studied and will be discussed.

33. Ring phenomenon on glass and quartz.

B. Dasannacharya *and* P. N. Aiyer, Benares.

Plates of glass and quartz were interposed very close behind the cathode. Rings could be obtained with exposures of only 15 minutes. With exposures of 1 hour the rings are exceedingly sharp and circular, and very striking colours due to deposits of zinc and copper, the materials of the cathode outside the ring system, present brilliant resonance colours. Well-defined deep colour is formed where the direct beam falls.

34. Bombardment of positive rays on metallic plates.

B. Dasannacharya *and* K. P. Rao, Benares.

Rings could be obtained on silver films on glass or where thin foils of silver are interposed. Plates and foils of brass and aluminium have also been studied, but the ring system is not very strikingly clear. Considerable disintegration of the metal takes place, and if the foil is thin it is punctured at the place struck by the direct rays.

35. Investigations of cathode fall.

B. Dasannacharya, V. T. Chiplonkar, *and* L. G. Sapre, Benares.

It is found that deposits due to hydrocarbons and sputtered metallic deposits are very sensitive indicators of the condition of cathode fall, and they can be easily noted since they are fluorescent. The characteristic changes observed when different voltages were put on were discussed.

36. A new method of investigation of cathode fall with ionic streams.

B. Dasannacharya *and* G. K. Das, Benares.

The method consists in letting into the cathode fall space a fine stream of gas. This stream gets ionized and the positively charged particles where they fall on the cathode excite fluorescence of a well-defined nature which is very sensitive to change in cathode fall. Photographs taken of these were projected and discussed.

37. Doppler-effect for H_β, H_γ, and H_δ, and its dependence on cathode fall.

B. Dasannacharya *and* G. K. Das, Benares.

The Doppler-effect has been studied with a very high resolving and light gathering three prism Steinheil spectrograph with high as well as low dispersion, cathode falls varying from 6 mm. to 12 cms. being used, and H_β, H_γ, and H_δ studied. It is found that the maximum Doppler-displacement varies linearly with cathode fall length.

38. Positive ray beam in cathode fall.

B. Dasannacharya *and* G. K. Das, Benares.

The dimensions of a positive ray beam have been studied under varying conditions of discharge, by means of a photographic camera and correlated with cathode fall length.

39. Cathode fall length and voltage in positive ray discharge.

B. DASANNACHARYA and G. K. DAS, Benares.

The dependence of cathode fall length on voltage is investigated and is shown that the former is more sensitive to voltage than a spark gap.

40. Doppler-effect of $H\gamma$ under very great dispersion.

B. DASANNACHARYA, L. G. SAPRE, and V. T. CHIPLONKAR, Benares.

Steinheil spectrograph with a teleobjective attachment to the camera side with an effective focal length of objective of 250 cms. has been used and the conclusion reached that the variation of the Doppler-displacement is linear with cathode fall length, provided the times of exposures and voltage are well controlled, and the discharge is maintained in very pure gas. Double maxima are not observed even in a single case.

41. Investigations on the continuous spectra of hydrogen in positive rays and the effect of mercury vapour.

B. DASANNACHARYA, V. T. CHIPLONKAR, and L. G. SAPRE, Benares.

Mercury vapour is shown to obliterate the discontinuities present between different types of continuous spectra in the ultraviolet.

42. Heavy water from electrolysis of water from deep wells.

B. DASANNACHARYA and V. T. CHIPLONKAR, Benares.

Several samples of heavy water have been prepared by electrolysis and their analysis carried out by determination of their density and refractive index. Some of these samples were exhibited and their yield discussed.

43. Investigations on Geiger point counters and cosmic radiation measurements.

B. DASANNACHARYA and P. G. NARAYANAN NAYAR, Benares.

Several types of point counters have been made and their performance studied with different types of electrometers. Their relative performance in the investigation of cosmic rays were discussed.

44. Investigations on Geiger line counters and measurement of cosmic radiation.

B. DASANNACHARYA and S. RAJARAMAN, Benares.

Line counters of different sizes were prepared and their performance investigated by applying the line electrodes to a set of thermionic amplifiers fitted with loud speakers. The fluctuations of counts against counts due to a standard source of radioactive material are studied.

45. Investigations on Foucault's pendulum of short lengths.

B. DASANNACHARYA and D. R. HEJMADI, Benares.

A pendulum has been constructed of length only 245 cms. and a bob of only 500 gms. in weight. It is shown that the Foucault angle of rotation can be determined to within less than 2% error. Careful and conclusive investigations have been made of the irregularities which

usually make the pendulum unusable unless the length is enormous and mass of the bob at least 20 to 30 times greater.

46. Investigation of second order effects with Foucault's pendulum.

B. Dasannacharya *and* D. R. Hejmadi, Benares.

The second order effect which is very small shows itself in the development of the orbit of the bob into a hypocycloid and is highly susceptible to errors. By a resonance method it is possible to observe this effect and the experimental value is in fairly good agreement with theory.

47. A new type of mercury still.

B. Dasannacharya, P. G. Narayanan Nayar, *and* V. Venkata Rao, Benares.

Without having to use a separate auxiliary pump a simple arrangement has been devised to get this vacuum by introducing a cylindrical type of condenser kept vertical and glass tap next to the boiler.

48. Study of the A.C. resistance change of nickel in longitudinal magnetic field.

M. M. Sen Gupta, H. B. Mohanty, *and* S. Sharan, Cuttack.

The magneto-resistance change of nickel has been measured by using an A.C. Bridge. It has been found that the phenomenon here is different from that observed in the case of D.C. resistance, inasmuch as there is less of hysteresis, a total absence of the residual effect and a different shape of the magneto-resistance curve. The magneto-resistance curve obtained with A.C. is also free from many irregularities often noticed with D.C., such as negative hysteresis, intersection of the different parts of the curve, and want of symmetry between the two halves of the curve for a complete cycle.

49. Theoretical discussions on the A.C. magneto-resistance of nickel.

M. M. Sen Gupta, H. B. Mohanty, *and* S. Sharan, Cuttack.

The A.C. magneto-resistance change of nickel has been plotted against the square of magnetisation and it is found that though the curve for increasing field becomes a straight line only after a certain magnetisation has been reached, that for the decreasing field is approximately a straight line throughout nearly the whole of its length. As the remanence in the case of the magneto-resistance change is zero, (*vide* previous abstract) this straight line, if properly manipulated, cuts the magnetisation axis giving a value of the magnetisation I_0, which has no effect on the resistance change of nickel and is due merely to the reversals of the magnetic elements of nickel. Theoretical qualitative explanations of the absence of remanence and of the shape of the curve as distinct from that obtained with D.C., have also been given.

50. A modified ripple method of measuring surface tension.

J. C. Kamesvar Rav *and* S. Venkara Raman, Hyderabad.

In the usual ripple method of finding surface tension, ripples are produced by a vibrating tuning fork and the surface is illuminated by

intermittent light of the same frequency, which is generally done with thy help of another fork or by using Fleming's motor vibrator as modified be Raman. This method entails great loss of light. The use of intermittent light can be avoided by forming stationary ripples either by reflection or on running water along a slanting surface, whose inclination can be adjusted. Either of those arrangements involve the use of steady light and can easily be used for measuring surface tension.

51. A theory of the surface tension of liquid metals.

D. V. GOGATE and D. S. KOTHARI, Baroda.

The object of this paper is to study the phenomenon of surface-tension from the point of view of the electron theory of metals. Using the free-electron model of Sommerfeld, and taking into account the Coulomb forces between ions and free electrons and the Fermi-Dirac distribution law, we have worked out a theory of the surface tension of liquid metals and have obtained the formula :—

$$S=\frac{1}{32}\frac{h^2\beta}{\pi m\, m_H{}^{4/3}}\left(\rho/A\right)^{4/3}+\frac{T}{4}\frac{dS}{dT},$$

where S is the surface tension of the liquid metal,
β is a constant, very nearly unity,
m is the mass of the electron,
m_H is the mass of the hydrogen-atom,
ρ is the density of the liquid metal,
A is the atomic weight,
and T is the absolute temperature.

The calculated and observed values of surface tension of the liquid metals Na, Ag, Cd, Zn, Hg, Pb, Bi, etc. are compared and the agreement is found to be fairly satisfactory.

52. A method of measurement of surface tension.

L. D. MAHAJAN, Patiala.

A method is devised to find the surface tension of liquids and solutions which are available in small quantities. The apparatus is merely a combination of Warren's surface tension balance (*Phil. Mag.*, Vol. vii, pp. 358–386, 1927), and T. Carlton Sutton's capillary tube (*Proc. Phys. Soc.*, Vol. 45, pp. 88–90, 1933). Warren's apparatus is used to control the pressure and Sutton's capillary tube to balance a small thread of a liquid. The method is suitable for viscous as well as mobile liquids.

The apparatus so devised is found to be very convenient to handle and quite sensitive. The surface tension of various liquids and solutions measured with it is found more accurate and reliable than that found by other methods.

53. On the measurement of quantity of light by the photo-electric cell.

D. V. GOGATE, D. S. KOTHARI, and U. K. PATWARDHAN, Baroda.

This is a continuation of the investigation already reported in the *Indian Journal of Physics*, Vol. 9, July, 1935, in which a method of using the photo-electric cell for the measurement of quantity of light was described and the two uses of the cell, viz. (i) for measuring the intensity of light, and (ii) for determining the quantity of light, were shown to correspond to the two uses of a galvanometer, viz. for measuring current and quantity of electricity respectively.

A Westinghouse photo-electric cell (type P.A.I.) which does not require any energising voltage is connected directly to a galvanometer, and the throws and steady deflections produced in the galvanometer are recorded for instantaneous and time exposures of the cell respectively.

Experiments are in progress with different types of photo-electric cells and an attempt is being made to use the photo-electric cell for measuring the quantity of light in discharges of short duration.

54. An experimental investigation of dilute liquid amalgams of zinc and lead with special reference to their electrical conductivity, viscosity, and density.

G. R. PARANJPE *and* H. R. REDKAR, Bombay.

This is a continuation of the work already published in the *Journ. Phys. Chem.*, Vol. 34, 1932, p. 2474, and the *Journ. Univ. Bombay*, Vol. II, Pt. II, 1933, p. 40. The effects of temperature on all these properties are also studied at the same time in the range 30° to 70°C. in a specially constructed large thermostat.

The amalgams are made electrolytically and all the different measurements are executed as rapidly as possible. No definite discontinuities are observed in the range examined so far.

55. Transport of silt.

S. R. SEN GUPTA, Sibpur.

Silts are transported by streams in two distinct ways. The bed silts are made to roll along the floor of the stream and the suspended silts are bodily carried forward by the water current. In this paper silts are considered as cylinders of circular cross section. For any definite channel velocity the maximum size of silt that can be just carried in suspension is obtained. The motion of this limiting size of silt is discussed. The rolling motion of the bed silt is also discussed. The paper is based on certain experiments carried out in the wind tunnel of the James Watt Engineering Laboratories of the Glasgow University.

56. Resistance of a conducting sheet of uniform thickness.

S. R. SEN GUPTA, Sibpur.

The resistance of a sheet of conducting material of finite width and of uniform thickness with a circular hole at the centre is discussed in this paper. The current and the potential functions have been obtained theoretically and experimentally. The increased resistance of the sheet due to the presence of the hole has been estimated and expressed in a form suitable for general use. There is close agreement between theory and experiment.

57. Note on a method of finding deflection.

S. R. SEN GUPTA, Sibpur.

The usual methods of finding the deflection of a beam are not at all suitable for finding the deflection when the load consists of a series of travelling loads such as locomotive wheels. The method given in this paper is perfectly general and well adapted to deal with stationary or moving loads. Several examples are worked out including one with standard Railway Board loadings.

58. Beams on elastic foundations.

S. R. SEN GUPTA, Sibpur.

Many cases occur in engineering practice when it is necessary to have a knowledge of the bending moments and shear forces on a beam on elastic foundation. Timoshenko has solved the problem when the beam is infinitely long. This paper deals with the above problem when the beam is of finite length under any type of loading. Stresses on a railway sleeper have been obtained. As an extension a method of determining the effective span of a beam resting freely at two ends on bearing plates is given.

59. A proof of the constancy of the velocity of light in a moving medium by means of negative spaces.

PANCHANON BHATTACHARYYA, Calcutta.

When a frame S' moves with uniform velocity v with reference to another frame S along a right line AB, the apparent velocity of light in relation to S' should be $c-v$ or $c+v$, according as it is projected along AB or BA. But the velocity of light is always found to be equal to c. Einstein has tried to reduce these unequal velocities to the same velocity c by changing the idea of time and space. The writer thinks there is a flaw in the entire method of procedure. A real proof of the phenomenon is obtained, without distorting time, by the application of Negative or Hyper-fine Spaces. (*Proc. Indian Science Congress*, 1935.)

The world is considered cylindrical, consisting of parallel lines or rays moving with uniform velocity c. When a rod PQ moves with uniform velocity v along PQ, its constituent rays become inclined at angle θ with PQ, such that $\sin\theta=\left(1+\frac{v^2}{c^2}\right)^{-\frac{1}{2}}$. Therefore, the new length=the breadth of the strip of rays=$PQ\sin\theta$. The resolved part of the velocity of light along the breadth of the strip=$c\sin\theta$. As the contraction of length and the motion of perpendicular to the breadth of the strip is inconceivable, the velocity of light will appear to be equal to c as before.

60. A note on Einstein's objection on the completeness of the quantum-mechanical description of reality.

D. S. KOTHARI, Delhi.

In a recent issue of the *Physical Review* (Vol. 47, page 777, 1935), Einstein, Podolosky, and Rosen have criticized the fundamental basis of quantum mechanics and have been led to conclude that the description of reality as given by a wave function is not complete. Temple (*Nature*, 135, 957, 1935) also has recently raised an objection which he considers 'destroys the whole structure of the modern form of the quantum theory'. The object of the present paper is to examine these criticisms and an attempt is made to show that they are not really justified. The arguments advanced in this paper are really all implied in Dirac's exposition of quantum mechanics (The Principle of Quantum Mechanics, 1935, chap. i–v), they being only present here in a form relevant to Einstein and Temple's criticisms.

61. Magneto-striction of degenerate electron gas.

D. S. KOTHARI, Delhi.

When degenerate electron gas is subjected to a magnetic field then some of the electrons are transferred to previously unoccupied higher energy-levels or phase-cells. This increase in null-point energy of the

electron gas means a corresponding increase in its pressure. If the pressure is to be kept constant, there must be a slight compensating increase in the volume of the degenerate gas. We thus immediately derive a formula for magneto-striction. An application is also made of Stoner's interesting results in his paper on the Thermodynamics of magnetization (*Phil. Mag.*, Vol. 19, page 565) to the above case of the electron degenerate gas.

62. The relation of gas pressure to radiation pressure in degeneracy.

D. S. KOTHARI, Delhi.

In the *Monthly Notices* (Vol. 93, page 82) the author has shown in a most general way that for an ideal gas, *degenerate* in the sense of Fermi-Dirac Statistics, the gas pressure exceeds the radiation pressure for both the fully relativistic and the fully non-relativistic limiting cases. In the present paper the above result is established by starting from the exact relativistic formula for the pressure of a degenerate ideal gas. This result is very significant in connection with the recent work on the theories of stellar structure, and the second part of this paper deals with this application to stellar structure.

63. Stationary optical paths.

D. S. KOTHARI, Delhi.

In a recent issue of *Nature* (Vol. 133, page 830) T. Smith has drawn attention to the erroneous but oft-quoted statement that optical paths are routes sometimes of minimum and sometimes of maximum times, and that for this reason we may refer to them simply as stationary paths. The correct statement is that the time happens to be a minimum when the path does not include an image of an end point of the rays considered, but that if the path includes such an image the time is neither a maximum nor a minimum, but is simply stationary. The author has pointed out that this correct formulation of the law of stationary path for optics is identical with the corresponding law of least action in particle-dynamics; and it is only thus that the full significance of the similarity between the properties of light and particle, so important in wave mechanics, is brought out. The quantum mechanical basis of the principle of least action is also discussed.

64. Contracting or expanding universe?

S. RAY, Lucknow.

In Sulaiman's Graviton Theory of gravitation, the solution for a planetary orbit is

$$u=\frac{\mu}{p^2}(1-2k\theta)+\frac{\mu}{p^2}Ee^{k\theta}\cos(\theta-\omega).$$

Of these, the first term gives an *expanding* solar system, and the second a *contracting* one.

This was pointed out in a paper communicated to Sir Shah Sulaiman on 20th October, 1934, and at the Symposium on Relativity at the U.P. Academy of Sciences, Allahabad, on 17th August, 1935.

The author is not aware of Sir Sulaiman having used this result of his anywhere in his five publications, including his paper before the U.P. Academy on the 17th August, or of his possibility of replying to the criticisms of Hamilton by withdrawing his approximate determination of the orbit of planets with the assumed identity of D and c, D and c being the velocity of gravitons and radions respectively.

65. The exploding atom of radioactivity in Sulaiman's graviton theory.

S. Ray, Lucknow.

Sulaiman has given two different, and perhaps contradictory, interpretations of '*ds*', the line element of Einstein, on pages 25 and 253 of the U.P. Academy Proceedings of 1934-5, Vol. IV. A totally different interpretation is given here by the present author based on Sulaiman's Physical Theory of Gravitation.

A matter particle is a stock of gravitons which is necessarily exhausting with time. '*ds*' is the change of state of this stock of gravitons.

$$ds^2 = -c^2 \cdot dt^2$$

represents the change of state due to lapse of *time*.

$$ds^2 = dx^2 + dy^2 + dz^2$$

represents the change of state due to change of *place*.

The total number of gravitons in a particle at any time t are

$$N = N_0 e^{-kt}$$

and the velocity of ejection of gravitons varies with time according to the relation

$$D = \mu k N_0 e^{-kt}.$$

66. On the 'first universal Principle' of Sulaiman.

S. Ray, Lucknow.

Sulaiman gives for the relative velocity of two particles, moving in a line with velocities u and v respectively, the expression

$$V = (v-u)\,\frac{1+\frac{v}{D}-\frac{u}{D}}{\left(1+\frac{v}{D}\right)\left(1-\frac{u}{D}\right)}.$$

This result rests on a fallacy of finding ds/dt from the values of ds and dt, when ds is in reality $d(s+ds)$. An examination of his arithmetic will show that to find ds he has evaluated the *final* distance apart between the two moving particles, and then finds its differential. When the correction herein pointed out is made, both Sulaiman's 'real velocity' as well as 'apparent velocity' come out equal to the Newtonian value of $(v-u)$. This is as it should be, as laws of Newtonian Dynamics were assumed by Sulaiman in the argument.

67. On Sulaiman's 'second universal principle' and Doppler effect by tangential motion.

S. Ray, Lucknow.

The Second Universal Principle of Sulaiman states that for tangential motion with velocity v, the force of gravity becomes $(1-v^2/D^2)^{\frac{1}{2}}$ times the force obtaining in case of rest.

It is shown that, by classical dynamics that is invoked, the factor should be $(1+v^2/D^2)^{\frac{1}{2}}$, the resultant being greater than D, the velocity of gravitons emitted by a mass at rest, and not less as Sir Sulaiman presumes.

Incidentally this criticism constitutes a criticism of one interpretation that Sulaiman gives of Einstein's 'line element', ds, which he bases on the assumption that the factor is $(1-v^2/D^2)^{\frac{1}{2}}$, viz. that ds is 'the projection of the effective path of light along the real direction'. (Chapter V, p. 253.)

It is also shown that the mathematical argument of this criticism will, for Sulaiman's radion emission of light, give a Doppler Effect by tangential motion.

68. The kinematics of Sulaiman and the dynamics of Newton.

S. RAY, Lucknow.

In a discussion on 1st October, 1934, after Sir Shah Sulaiman's address in Lucknow, it was pointed out by the present author that Sir Sulaiman was getting attraction out of bombardment by withdrawing gunners from the side of the attracting particle facing the attracted one.

In the U.P. Academy Symposium on Relativity on 17th August, 1935, it was pointed out that Sir Shah Sulaiman was getting 'self-acceleration' by arranging to put more gun-powder in the rear guns than the front ones on the surface of the moving particle.

69. On a quantum mechanism in Sulaiman's graviton theory of gravitation.

S. RAY, Lucknow.

If a particle move tangentially round a source of graviton emission, starting from the space between two gravitons at any instance, it can come to the same position again without experience a single 'hit', or what is the same thing, without experiencing any gravitational force. If the velocity is increased, it is easy to see that if in the time of one graviton taking up the position of the graviton immediately preceding it the attracted particle describes a whole number of revolutions round the attracting particle in addition to the space separating the line of fire of two consecutive machine guns of Sulaiman's *jins* (analogous to Maxwell's demons), the zero value of the gravitational force will repeat itself.

It can also be seen that a small change of 'phase' of motion of the attracted particle will make the force of gravitation jump up from a zero value to a maximum, when it shall be hit by absolutely all the gravitons as it goes round the attracting particle.

The line of fire will be straight lines separated by gaps. With small particles at sufficient distance from the attracting particle, a fine structure effect will be obtained.

70. The quantum theory and scattering of light from liquid surfaces.

S. RAY *and* S. C. ROY, Lucknow.

In any emission theory of light, like the corpuscular theory of Newton or the radion theory of Newton, the projectile cannot be larger than the source of emission, the molecule, the atom or the electron.

In the surface of the liquid molecules are arranged in all kinds of possible orientations. They are, moreover, rapidly changing their orientations with time. Therefore the *scattering* will be very great.

In a *wave* theory, the wavelength is very much longer than the source. Huyghen's construction will give a good reflection and very small scattering.

The virtual absence of scattering from liquid surfaces should, therefore, be added to the list of phenomena against the quantum hypothesis given by Jeans in his Dynamical Theory of Gases, 3rd edition, p. 378.

Incidentally it is pointed out that propounders of quantum and emission theories of modern age avoid the compliment to Newton which the designation 'corpuscles' could convey, because they are aware that in the history of physics it has been decided once for all that corpuscular theory will give a greater velocity for light in the denser medium than in

the rarer one. By using the term quant, dart, or radion, they think they avoid that difficulty which a specific emission theory necessarily encounters.

71. On tidal waves in a thin shell due to a molten interior separated by a vapour cushion.

S. RAY, Lucknow.

In a paper submitted to the *U.P. Academy of Sciences* on 16th August, 1935, it was shown that the 'trigger action' admitted by Prof. A. C. Banerji as being caused by the alignment of moon and planetary bodies, in the Calcutta Science Congress Symposium on the Behar Earthquake, becomes a direct action for a thin shell which the earth's crust necessarily is.

Substances which expand on solidification will just form the earth's crust. Those that contract on solidification will then separate from this crust.

This will keep the interior source hotter and more 'liquid' than our solid or liquid continuum extending to the centre of the earth made it, and explain the incidence of severe earthquakes near new and full moons as in Behar and Quetta.

72. On correct evaluation of Ball's ratios for glacial and genial ages.

S. RAY, Lucknow.

Ball assumes the sun heat received in northern and southern hemispheres with declination δ to be

$$\frac{H}{a^2}(1+\sin\delta) \quad \text{and} \quad \frac{H}{a^2}(1-\sin\delta)$$

where $2H/a^2$ is the quantity of sun heat falling perpendicularly on an area equal to the section of the earth at the mean distance a from the sun in unit time.

It can be seen that if we consider the northern and southern hemispheres, a factor $\frac{1}{2}$ should be affixed to the term $\sin\delta$ in the expressions.

When this is done, the variation of Mean Daily Sun Heat in summer and winter, for the Glagical Age, are in the ratio

$$1{\cdot}22 : 0{\cdot}78$$

as against 1·38 : 0·68 of Sir Robert Ball. It is, in fact, better than his 'Present Age' Ratio, which is given as

$$1{\cdot}24 : 0{\cdot}75.$$

This corrected value is submitted as a support of Wegener's Continental Drift Theory.

73. Floating continents and the energetics of a cooling shell in rotation.

S. RAY, Lucknow.

Geikie clearly points out that requisition of Astronomical Theories of Glaciation is a kind of last resort for Geologists.

In the Symposium of the American Petroleum Geologists in 1928, the remarks of van der Gracht indicated that oceans may rest on molten magma in a spheroidal state supported on a cushion of vapour.

So-called Quantum Dynamics owes its success to exploiting the Principle of Conservation of Energy of Newtonian Dynamics in problems

of Physics, without going into the details of processes involved. The Principle of Conservation of Rotational Energy can be exploited for problems in Geophysics with profit.

Sial crust resting in the spheroidal state over liquid magma will form into a circular patch round a pole on account of the Principle of Smooth and Balanced Rotation.

This patch on cooling will alter the moment of inertia of the earth, and therefore its period of rotation. To stop it, forces will be brought into play.

In a previous paper communicated to the Indian Science Congress it was submitted the forces making for diurnal and secular variation of the earth's magnetic and electric fields was due to such causes. (1919.)

In this paper it is shown this will supply us with physical forces producing geological changes for which geologists have no explanation.

Forces acting at right angles to the axis of the earth's rotation will obviously arise. It will give an *elevating force* which is a maximum at the equator and drops to a zero value at the poles. It will also bring about, by a *tangential force* which is zero at the poles and at the equator and a maximum at latitude of 45 degrees, north and south, a tension and compression of the kind postulated by Wegener. In a paper on the Formation of Fold Mountains in the Indian Science Congress, 1935, a theory has been given of sinuous waves parallel to the equator. The stresses here shown will give folds of which the direction of the wave is parallel to the meridians.

The tearing force will also give radial rifts and supply measure of the quantitative force for tearing asunder of continents which geologists want, as well as indicate the date of the event.

Glaciation requires for explanation sudden changes of climate rather than slow processes of Astronomical Theories. The energetics of a rotating shell, floating on a vapour cushion above a molten magma, furnishes forces bringing about such sudden changes.

Detached islands, by their translatory motion parallel to the meridian, as well as by elevation, would act like governors in regulating the period of rotation of the shell.

74. Nehruization of fans.

S. Ray, Lucknow.

S. S. Nehru, in 1916, did some researches at the Muir Central College on the effect of collars or ecranges round screws, in increasing their efficiency.

These results were sought to be utilized for ventilating with a single table fan the M.Sc. Part I Practical Hall (Heat Section) without disturbing the dozen experiments on the tables along the length of the hall. The hall is 35 feet by $15\frac{1}{2}$ feet and the space in the middle is reserved for seats for calculation work.

An 'ecrange' of sheet iron of diameter 15″ and length 2 feet mounted in front of the fan blades gave a 'beam' breeze along the axis of the hall where the seats for calculation are provided.

The arrangement was suggested in a 'Report on the Acoustic Correction of the U.P. Council Chamber' submitted to the Hon'ble the President, U.P. Legislative Council, and the Secretary to Government, P.W.D., Buildings and Roads, on 10th June, 1934.

To study the thrust produced by the screening system the fan is suspended by a bi-filar suspension from the roof.

75. On sums of powers and primes.

I. Chowla, Waltair.

Generalizing a method used by S. S. Pillai it is shown that for any integer $n \geqslant 3$ there exists a $Y = Y(n)$ such that all large integers $\equiv 3 (Y)$.

are sums of $(n+2)$ nth powers of positive integers and 2 primes. This theorem is now when n is a power of 2.

76. On Waring's problem.

I. CHOWLA, Waltair.

Using the method recently developed by Vinogradoff it is shown that if n be an integer >3 and

$$s=[n(6 \log n+\log 216+4)]$$

then for every integer $N \geqslant c=c(A,n)$ we have

$$N=t_1^n+\ldots+t_s^n$$

where the t's are integers greater than an arbitrary positive A.

77. A type of non-static solutions of the equation $G_{pq}-\frac{1}{4}\, g_{pq}G=-8\pi T_{pq}$.

J. GHOSH, Calcutta.

Einstein proposed the above equation for the gravitational field of an electron (*Math. Ann.*, 1926) and it was solved by the author with reference to several fundamental cases of radially symmetric fields (*Z. fur Physik*, 85,511 ; 1933 ; and 94,411 ; 1935. Also *Nature*, July, 1933 ; July, 1935). The author obtains in this paper a type of non-static solution of the above equation.

78. On certain new connections between Legendre and Bessel functions.

S. C. MITRA, Dacca.

In the *Bulletin of the Calcutta Mathematical Society* (Vol. 25, No. 2, 1933, p. 81) and the *Proceedings of the Edinburgh Mathematical Society* (Vol. IV, part III, 1935) several new connections between Legendre and Bessel Functions were obtained. In the present paper, several more new connections have been obtained.

79. On solution of a certain type of difference equations compared with those of their analogues in ordinary differential equations.

P. N. DAS GUPTA *and* V. R. CHARIAR, Patna.

It has been shewn that while in Clairauts' type, in its generalized and ordinary form, there exists some similarity between periodic types of solutions with ordinary solutions, there are in the case of finite differences certain peculiarities which do not allow of an extension to the case of continuous variables. Some particular solutions with definite periodic functions are discussed as to their bearings with reference to other solutions.

80. On concomitants of two quadrics associated with two linear complexes.

P. N. DAS GUPTA *and* NITYANANDA CHATTERJEE, Patna.

One of the authors (Das-Gupta) has considered the concomitants of two quadrics associated with a linear complex in *Proc. Lond. Math. Soc.*, Ser. 2, Vol. 31, pt. 7. In the present paper corresponding concomitants with associated Geometry have been obtained in the case of two quadrics associated with two linear complexes.

81. On the evaluation of the probability integral of the D^2-statistics.

RAJCHANDRA BOSE, S. N. RAY, *and* P. C. MAHALANOBIS, Calcutta.

The exact distribution of the D^2-statistics, constructed by P. C. Mahalanobis in an attempt to estimate the divergence between two populations, was found by one of the authors in the form which after the substitutions

$$\lambda^2 = \tfrac{1}{2}\bar{n}P\Delta^2, \quad L^2 = \tfrac{1}{2}\bar{n}PD_1^2$$

can be written as

$$F_P(L, \lambda)dL = \left(\frac{L}{\lambda}\right)^{\frac{P}{2}-1} Le^{-\frac{1}{2}(L^2+\lambda^2)} I_{\frac{P}{2}-1}(L\lambda)dL$$

where D_1^2 is the uncorrected sample value, and Δ^2 the population value of D^2, and I is the Bessel function of pure imaginary argument. The object of the present paper is to obtain the numerical value of the incomplete probability integral

$$\phi_P(L, \lambda) = \int_0^L F_P(L, \lambda)dL.$$

It is proved that

$$\phi_P(L, \lambda) = \phi_{P-2}(L, \lambda) - f_{P-2}(L, \lambda)$$

where

$$f_{P-2}(L, \lambda) = \left(\frac{L}{\lambda}\right)^{\frac{P}{2}-1} e^{-\frac{1}{2}(L^2+\lambda^2)} I_{\frac{P}{2}-1}(L\lambda).$$

The function f obeys the recurrence formula

$$f_P(L, \lambda) = -\frac{P-2}{\lambda^2} f_{P-2}(L, \lambda) + \frac{L^2}{\lambda^2} f_{P-1}(L, \lambda).$$

This enables us to make $\phi_P(L, \lambda)$ depend upon $\phi_2(L, \lambda)$ or $\phi_1(L, \lambda)$ according as P is even or odd.

We show

$$\phi_1(L, \lambda) = \frac{1}{\sqrt{2\pi}} \int_{\lambda-L}^{\lambda+L} e^{-\frac{1}{2}t^2} dt$$

which can be found from the tables of the probability integral. Also $\phi_2(L, \lambda)$ is obtained in the form of the following convergent series:—

$$\phi_2(L, \lambda) = 1 - e^{-x} \sum_{n=0}^{\infty} \frac{x^n}{n!} \left\{ 1 - e^{-\xi} \sum_{m=0}^{n-1} \frac{\xi^m}{m!} \right\}$$

where

$$x = \tfrac{1}{2}L^2, \quad \xi = \tfrac{1}{2}\lambda^2.$$

The actual numerical computation is proceeding in the Statistical Laboratory, Presidency College, Calcutta.

82. On the generalized measure of divergence between statistical groups.

P. C. MAHALANOBIS, Calcutta.

A generalized distance between the mean values of two statistical groups called D^2, which has been discussed elsewhere, has exactly the same form as the expression for the interval (ds^2) in the theory of relativity. This suggests one possible method of generalizing the expression for the statistical distance (D^2) in the same way as the interval in the gravitational theory of relativity. On the basis of this formal identity every theorem in relativity involving the interval has an exact analogy in statistics. For example, the Lorentz transformation is recognized to represent in statistics a transformation of the variables in such a way as to make the transformed variables statistically independent. The generalization of D^2 in analogy with the general theory of relativity requires, however, that the coefficients of correlation and the variabilities should be functions of the co-ordinates, that is, of the size of the characters. It is not known how far this condition is satisfied in actual statistical fields.

It has been therefore considered desirable to develop alternative methods of measuring the generalized divergence between statistical groups. Confining our attention to multivariate linearly correlated normal populations, it has been found convenient to represent the difference between mean values as a geometrical distance; the difference between correlations as a hyper-dimensional rotation, and differences in variabilities as a difference in the size of the density-ellipsoids. Possible expressions for the generalized divergence as well as sampling distributions are under investigation by Rajchandra Bose and Samarendra Nath Ray.

83. A statistical analysis of marks obtained in a University examination.

B. C. DAS *and* D. N. SEN, Calcutta.

84. On the rate of disappearance of the proper motion of a nebula in the theory of an expanding universe.

N. R. SEN, Calcutta.

85. Determination of lines of flow and uplift pressure on works on sand foundation.

N. K. BOSE *and* H. L. UPPAL, Lahore.

As most of the Irrigation Works such as dams, weirs and falls are on sand foundation, it is of great importance to practical engineers to know how the flow lines distribute themselves below their hydraulic structures. It is well known that if there is a concentration of flow lines at the toe-end of the structure there is a danger to the Works.

So that the determination of such flow lines has been one of the most important problems for hydraulic engineers in Europe and America where they have tried to trace it by putting dyes along with the flowing liquid on the entrance end of the structure. The streamlines so traced used to be very faint and dispersed specially where the pressure gradient was very small. To overcome this trouble the method developed by Dr. E. McKenzie Taylor, Director, Punjab Irrigation Research Institute, has been successfully used to trace these lines of flow. This method consists in passing a weak solution of potassium chromate instead of water through the sandy foundation in a model tank and then introducing silver nitrate solution at a number of points on the entrance side.

This solution of silver nitrate as it flows in the sandy medium and comes in contact with the potassium chromate solution leaves a dark red precipitate of silver chromate as distinct lines of flow which can be photographed easily.

The distribution of pressure on the sandy medium has also been observed by putting in brass nipples at definite points in the sides of the tank and by connecting them to water manometers outside. By this means it has been possible to get distribution of pressure and from them to derive mathematically the lines of flow. Agreement between these lines of flow and those obtained from the photograph is very good.

It has been found possible to get the complete pressure distribution round different hydraulic structures by combining a couple of streamlines with about half a dozen pressure observations distributed suitably round the model. This has led to get economy of time and labour.

86. On the theory of Ionosphere. Part I.

D. S. KOTHARI *and* R. C. MAJUMDAR, Lahore.

Assuming that the Ionosphere consists of ions and free electrons the current density, dielectric constant, etc. have been calculated in §1, following Dirac's method of variation of constant. In §2 the effect of damping has been considered after Wigner and Weirskopf and the frequency of collisions calculated and compared with observations.

Section of Chemistry.

President:—P. C. GUHA, D.Sc., F.N.I.

Presidential Address.

RECENT DEVELOPMENTS IN THE CHEMISTRY OF BICYCLIC TERPENES.

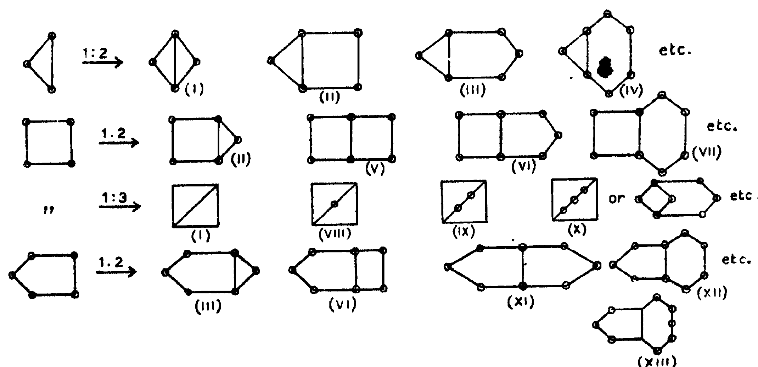
In opening this address I wish to express my high sense of honour in being invited to preside over the deliberations of this Section. I cannot hope to serve you as my distinguished predecessors in this Chair, some of whom I am very glad to see here to-day, but I can claim to be as much in earnest for promoting its aim, and being fully aware of my own limitations, I venture to hope that with your friendly co-operation we may make the session a success.

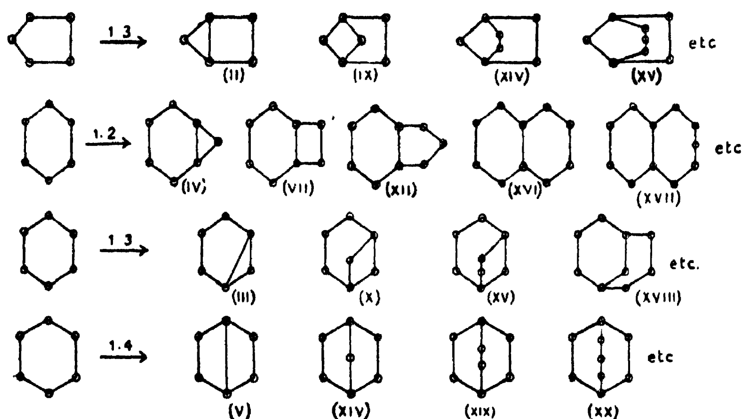
Next, I feel it is our duty to pay our most respectful tribute to Sir P. C. Ray, the father of chemical research and industry in India. Let us all pray to Almighty God that this 'Grand Old Scientist' may be spared to advise and guide Scientific India for very many years to come.

It is difficult to select a subject to suit the taste of an audience comprising votaries of all the different branches of chemistry: but following the example of many predecessors, I have decided to deal with a subject in which, at the present moment, I and my student co-workers are taking an active interest.

INTRODUCTORY.

Before discussing the recent developments in the chemistry of bicyclic terpenes, it is desirable to say a few words about



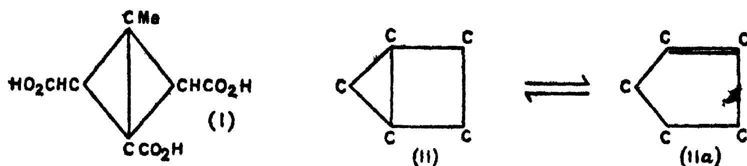


bicyclic ring systems in general. As appears from the above diagrams, the number of possible bicyclic ring systems is large. Some are found to exist in naturally occurring terpenes whilst among the remainder some are known only by synthesis.

Similar bridge formation is possible with *cyclo*heptane and other polymembered rings. Bicyclic ring systems are composed of two rings united directly in the *ortho* position, or having more than two carbon atoms common to both rings. It is proposed to give only a short description of the more important systems with their salient features.

Derivatives of the system (i) are known only through synthetic investigations. Beesley, Ingold, and Thorpe[1] have prepared three stereoisomeric forms of 1-methyl-bi*cyclo*-(0 : 1 : 1)-butane-2 : 3 : 4-tricarboxylic acid (I) starting from ethenyl triacetic ester.

Bi*cyclo*-(0 : 1 : 2)-pentane (ii) in which a *cyclo*butane ring is fused to a *cyclo*propane ring, is apparently tautomeric with its monocyclic form (ii*a*). Support for structure (ii) for compounds of this group is available through oxidation experiments giving compounds of the type of caronic acid,[2] while their optical behaviour and chemical properties point to the existence of the *cyclo*pentene ring.

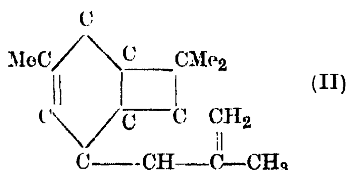


The next ring system, bi*cyclo*-(0 : 1 : 3)-hexane (iii) occurs in naturally occurring terpenes, like thujane (vide *infra*) and copaen.[3] Compounds of bi*cyclo*-(0 : 1 : 4)-heptane (iv) group are discussed under the carane series.

The next important ring system is bi*cyclo*-(0 : 2 : 2)-hexane (v). Zelinsky[4] claims to have obtained the parent hydrocarbon by the action of sodium on *cis-p*-dibromo*cyclo*hexane. Under identical conditions, *trans-p*-dibromo*cyclo*hexane does not yield the hydrocarbon.

Bi*cyclo*-(0 : 3 : 3)-octane (xi) and its derivatives have proved to be of considerable importance from the stereochemical standpoint. Willstätter[5] obtained the parent hydrocarbon for the first time and later Schröter[6] claimed to have synthesized certain derivatives of this group but according to Linstead[7] (cf. also Ruzicka *et alia*[8]) all these compounds 'are of doubtful constitution'. This ring system has been found to occur in the product of degradation of desoxycholic acid.[9] The contributions of Linstead and his collaborators on the stereochemical aspect of this ring system are significant and will be described later.

No compound is definitely known belonging to the bi*cyclo*-(0 : 2 : 4)-octane system (vii), but it is interesting to note that Ruzicka[10] has assigned to caryophyllene the structure (II).



(II)

Bi*cyclo*-(0 : 3 : 4)-nonane (xii) is hydrindane and its derivatives have formed the subject of important stereochemical investigations by Hückel. Azulene, the sesquiterpene hydrocarbon isolated by Ruzicka, has probably the same ring skeleton.[11] Compounds of the bi*cyclo*-(0 : 3 : 5)-ring system (xiii) are known only by synthesis.[12]

Coming to the ring system (xvi), bi*cyclo*-(0 : 4 : 4)-decane, occurs in sesquiterpenes and also in compounds like santonin, alantolactone, etc. Decalin, the parent hydrocarbon of this group and its derivatives, have been synthesized by a large number of well-known reactions. Incidentally, it might be mentioned that it was in decalin and its derivatives, that Hückel for the first time discovered the isomerism arising out of the *cis* and *trans* lockings of two monocyclic rings.

In the bi*cyclo*-(0 : 4 : 5)-undecane system (xvii), only such derivatives[13] have been met with in which the 6-carbon ring is benzenoid in nature.

The bi*cyclo*-(1 : 1 : 3)-heptane ring system (x) is present in a large number of compounds of the pinane series, while bi*cyclo*-(1 : 2 : 2)-heptane (xiv) is the parent hydrocarbon of all the compounds of the camphane, fenchane, and santane series.

The bi*cyclo*-(2 : 2 : 2)-octane (xix) is of interest since Hückel[14] finds (by calculation) the molecule to be practically free from

strain. Other compounds of this group have been made known through the 'diene' synthesis of Diels-Alder[15] as also by Komppa's synthetic work[16] starting from hexahydrohomoterephthalic acid. Work in this laboratory has shown that ethyl disodio-succinosuccinate reacts under suitable conditions with ethylene bromide to furnish the corresponding *p*-bridged diketo-ester.[17]

The next ring system of importance, bi*cyclo*-(1 : 2 : 3)-octane (xv) to which *endo*camphene, homocamphenilone, homocamphor, homo*epi*camphor, etc. belong, is known only by synthesis.

Derivatives of bi*cyclo*-(1 : 3 : 3)-nonane (xviii) have been synthesized by Meerwein[18] by condensing methylene*bis*malonic ester with methylenemalonic ester in presence of sodium ethoxide. Rabe[19] on the other hand obtained the corresponding bi*cyclo*-nonane derivative by interaction of methyl*cyclo*hexenone and acetoacetic ester. It is interesting to note that the bi*cyclo*nonane molecule is absolutely free from strain.

Disposition of bicyclic rings in space.—The very significant contributions of Hückel[20] in the chemistry of decalins and the discoveries of Ruzicka on the polymembered carbon rings, provided strong arguments against Baeyer's uniplanar structures for *cyclo*hexane and higher carbon rings. It was shown long ago by Mohr[21] that two isomeric decahydronaphthalenes can be formed by the fusion of two strainless *cyclo*hexane rings in two different ways. The two rings are locked either by their *cis* or their *trans* valencies in such a way that interconversion of the types is not possible. Thus the existence of two decalins, and of four racemic forms of mono-substitution products (derived in pairs from the *cis* and the *trans* forms) could be predicted.



Hückel's experiments have shown this actually to be the case, leading to the conclusion that *cyclo*hexane rings in decalin lie in different planes. At any rate, this must be so for *trans*decalin, since it cannot result from the fusion of two planar *cyclo*hexane rings. According to Richter 'it is therefore difficult to understand how Haworth[22] reaches the conclusion that the phenomena of isomerism are compatible with the assumption of planar *cyclo*hexane rings'. Further, the experiments of Rao[23] have confirmed the stereochemical deductions from Mohr's model of decalin.

The investigations of Hückel and Friedrich[24] and later of Kandiah[25] in the hydrindane series, have established the existence

of two stereoisomeric ring systems. Structural considerations would allow the formation of two stereoisomeric *cis*-hydrindanols and only one *trans*-hydrindanol from the corresponding hydrindanones on reduction. This has been experimentally confirmed.

Linstead and his collaborators [26] have extended the researches of Hückel to *cis* and *trans* bi*cyclo*-(0 : 3 : 3)-octane derivatives. Linstead and Barret[26a] discuss the evidence and its bearing on the tetrahedral theory of ring-strain (Sachse-Mohr). The conflicting evidence obtained so far in this field as regards energy content and stability of bicyclic *cis* and *trans* types, would seem to indicate 'that the stability of bicyclic rings, and hence by implication of single rings, may be affected to a greater extent than has been previously thought, by factors other than strain, in particular the repulsive forces of the constituent atoms'.

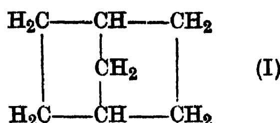
In passing, it might be mentioned that '*cyclo*hexane has still to rid itself of or adopt the Sachse-Mohr hypothesis'. The large amount of work carried out by South Kensington school of workers would seem to point to a strained and uniplanar structure for *cyclo*hexane. Side by side with this, definite isolation of *simple* isomeric *cyclo*hexane derivatives has been claimed, consistent with two multiplanar configurations for *cyclo*hexane. The claim of Khuda [27] regarding the isolation of four forms of 4-methyl*cyclo*hexane-1-carboxylic-1-acetic acid could not be substantiated by the independent investigations of Goldschmidt and Gräfinger,[28] and Desai and Hunter.[29] Considerable doubt has been thrown on his other claim [30] by the recent investigations of Linstead and Dey.[31] As there is no satisfactory experimental evidence for the Sachse-Mohr hypothesis, and as the energy required for the interconversion of the two forms appears to be small, any such claim [32] has to be accepted with reserve.

The question naturally arises whether such isomerism can possibly exist in bicyclic compounds with rings locked in the 1 : 3-positions. Although theoretically possible, it is difficult to say whether the *trans*-lockings in such cases with attendant strain in the molecules would permit their existence.

Camphane Fenchane Series.

The problem that confronts one attempting a resumé of recent developments in this field is not one of minor importance or difficulty. This field, which includes the chemistry of camphor and its degradation products, can boast of a brilliant band of chemists of the type of Wallach, Semmler, W. H. Perkin Jr., Bredt and Komppa, amongst others for its devotees, and they have patiently toiled at it with remarkable success. The wonderful molecule camphor, the simplest of whose derivatives are capable of existing in a number of isomeric forms, has

proved to be an inexhaustible source of experimental results. Witness, the recent work of K. Miyake [1] who has isolated for the first time 6-ketocamphor from the oxidation products of camphor with chromic acid. Side by side with the synthesis of degradation products there has been active synthesis of certain parent compounds. The parent hydrocarbon of the camphor group norbornylane (I)—as Komppa would call it—was synthesized only last year by Komppa and Beckmann.[2]



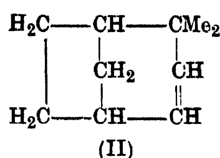
The very large amount of synthetic work applied to degradation products of this series has been facilitated in no small measure by the correct formulation of camphor by Bredt, and the classical syntheses of camphoric acid by Komppa [3] and by Perkin and Thorpe.[4] Much remains still to be done especially among compounds of .the fenchane series.

In what follows, an attempt will be made to review the very recent synthetic developments in this field. The tricyclic compounds derived from members of this series will also be discussed. Camphor and its derivatives have been used in medicine from time immemorial and no apology is needed for the inclusion of a small section on the relation between physiological effects of these compounds and their chemical structure. The 'Wagner Rearrangement' and the more recent 'Nametkin Rearrangement' are dealt with rather briefly from the point of view of their mechanisms.

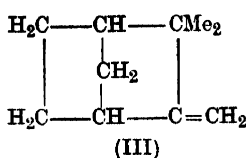
Syntheses of Parent Compounds.

It is noteworthy that the number of parent compounds occurring in nature is very meagre. With the exception of camphene, borneol, fenchyl alcohol, *iso*fenchyl alcohol, camphor and fenchone, practically all the other fundamental compounds from which an amazing number of complex substances are derived, have been obtained artificially in the laboratory, and it is with them that we are mainly concerned.

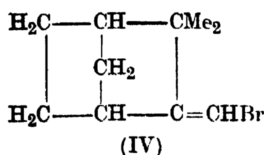
Endocamphene (II) has been synthesized by Lipp, Gotzen, and Reinartz,[5] and this has definitely laid at rest the Wagner structure of camphene with an exocyclic bond (III). Aschan [6] had suggested the formula (II) for camphene. Lipp *et alia* find that ω-bromocamphene (IV) on treatment with alkali yields R-homocamphenilone (V) which on reduction to the corresponding alcohol (VI) and subsequent dehydration furnishes endocamphene (II).



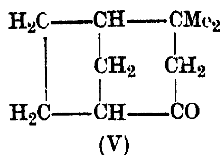
(II)



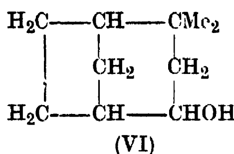
(III)



(IV)

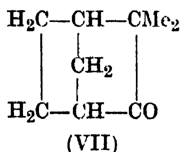


(V)

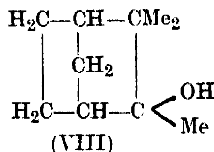


(VI)

In this connection it may be noted that the synthesis of camphene[7] (III) starting from camphenilone (VII) *via* methyl camphenilol (VIII) by dehydrating the latter with acids is open to doubt, it being well known that camphene isomerises in presence of acids.

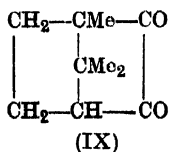


(VII)

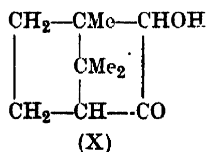


(VIII)

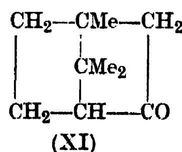
Bredt and Bredt-Savelsberg[8] have reported a new synthesis of *l-epi*camphor (XI) starting from camphorquinone (IX). The latter on reduction in acid or neutral solution yields 2-hydroxycamphor from which α-hydroxycamphor (X) has been obtained pure and this on treatment with NaHg furnishes *l-epi*camphor.



(IX)

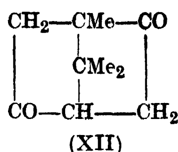


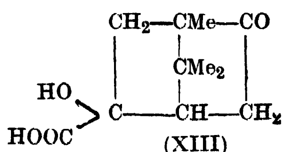
(X)

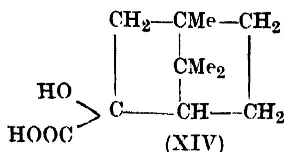


(XI)

Asahina and Ishidate[9] have synthesized *d-epi*camphor (XI) starting from *d*-5-ketocamphor (XII). Addition of KCN to the latter takes place exclusively at the 5-carbonyl group yielding a mixture of α- and β-hydroxynitriles, the corresponding α-5-hydroxycamphor carboxylic acid (XIII) gives α-5-hydroxycamphanecarboxylic acid (XIV) which on oxidation gives *d-epi*camphor (XI).



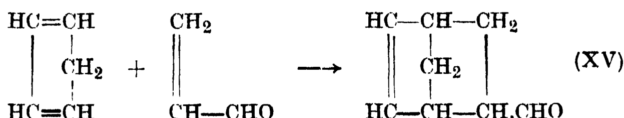




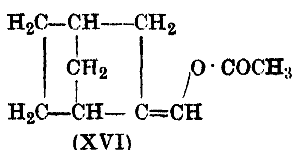
The syntheses of α-fenchocamphorone and α-fenchene[10] by Komppa and Roschier and fenchone by Ruzicka[11] famous and fairly old as they are need no reiteration.

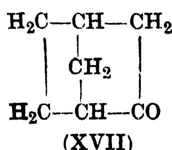
The discovery of Diels and Alder in 1928 that a conjugated series of double bonds, a ' diene ' system, could combine additively in the 1 : 4-positions with other substances containing the group —CH=CH—CO, such as maleic anhydride, acrolein, etc., has furnished the organic chemist with a most powerful weapon for the synthesis of many complicated ring systems. Diels and Alder have already covered much ground in their synthetic work with this new reaction, and in the field of bicyclic terpenes have used it with conspicuous success.[12]

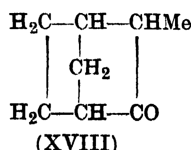
*cyclo*Pentadiene accepts acrolein quantitatively thus :—



The resulting bridged aldehyde (XV) is a very convenient source for the synthesis of camphor compounds. The enol acetate (XVI) corresponding to (XV) after reduction, yields on ozonolysis norcamphor (XVII) (previously synthesized by Komppa and Hintikka starting from ethyl *cyclo*pentanone-3-carboxylate.[13]) On alkylation with $NaNH_2$ and CH_3I, norcamphor yields successively 2-methyl-norcamphor (XVIII) and camphenilone (VII).

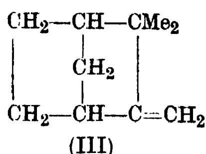


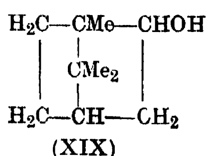


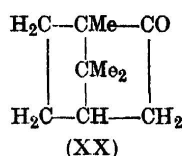


The synthesis of camphene from camphenilone, through camphenilol, according to the method mentioned elsewhere, is also described by Diels and Alder.

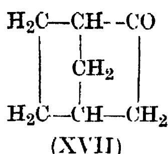
Camphene is converted by Bertram-Walbaum's reaction to a mixture of borneol and *iso*borneol (XIX) which is oxidized to camphor (XX).

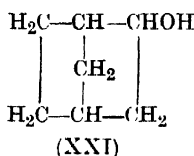


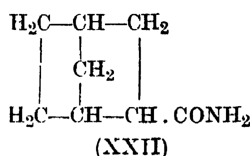




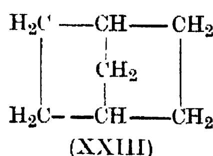
Komppa and Beckmann[2] have reduced norcamphor (XVII) catalytically to the corresponding α-norborneol (XXI). The diastereoisomeric β-norborneol is obtained from the amide of bi*cyclo*-(1 : 2 : 2)-heptane-2-carboxylic acid (XXII) *via* the amine.

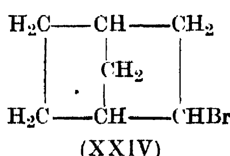


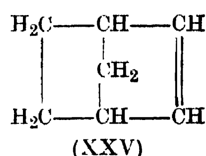




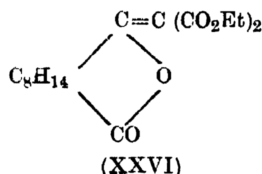
Norbornylane (norcamphane) (XXIII) is obtained from β-norborneol through its chloride or bromide (XXIV) by reducing these with sodium and alcohol. The bromide (XXIV) gives norbornylene (XXV) when heated with quinoline.

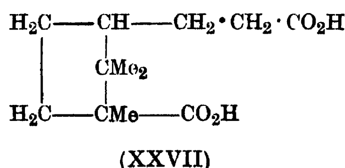


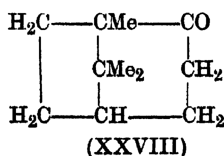




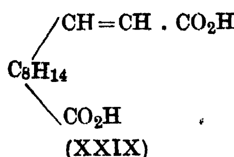
Two isomeric *homocamphors* (XXVIII, XXXI) have been synthesized by Lapworth and Royle[14] and by Salmon Legagneur.[16] Winzer's camphorylmalonic ester[15] (XXVI) on reduction and hydrolysis gives hydrocamphorylacetic acid (XXVII) the lead salt of the latter furnishing homocamphor in the usual way.

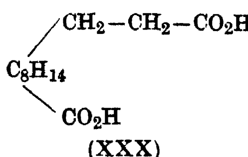


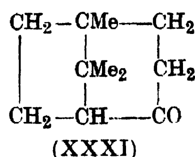




d-β-Homocamphor (XXXI) has been prepared by Salmon Legagneur starting from camphoric acid semialdehyde. The methyl ester of this condenses with zinc and bromoacetic ester to give the unsaturated ester (XXIX). The free acid when reduced in presence of platinum oxide by Adam's method, yields α-carboxycamphocean-β-propionic acid (XXX) the lead salt of which gives β-homocamphor.







The same author has also converted the above β-homocamphor by an interesting series of degradation reactions to *l*-*epi*-camphor.[17]

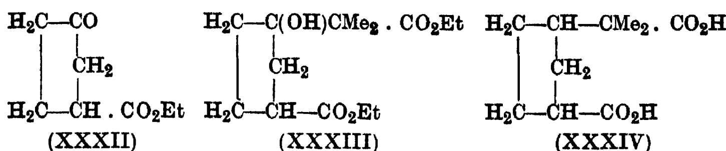
Komppa and Hasselstrom [18] have described the preparation of a number of hydrocarbons like fenchane, *apo*camphane, β-*apo*fenchane, santenane from the hydrazones of corresponding ketones by treating them with sodium and alcohol. Nametkin has published a series of papers during the last 10 years on the homologues of camphor. It is but to be expected that *apo*camphor (α-fenchocamphorone) should lead to as many interesting derivatives as camphor itself but unfortunately not much work seems to have been done on this compound. This might be attributed in a way to the difficulty with which this compound is obtained.

Degradation Products.

In the carane, thujane, and pinane series many important degradation products remain yet to be synthesized and their constitution definitely ascertained. In the fenchane and camphane series the case is altogether different due possibly to the ease of 5-membered ring formation compared with that of 3- and 4-membered rings. It must be recognized that although the synthetic work in degradation products has ceased to be spectacular during the last decade, it has nevertheless been steady and continuous. It is very encouraging to note, however, that the syntheses of degradation products in the fenchane series has of late received great attention.

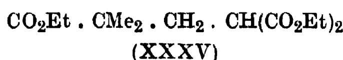
The brilliant synthesis of camphenic acid, an interesting oxidation product of camphene, by Lipp [19] furnished at once a method for introducing a lengthened side chain in the *cyclo*-pentane ring, and this method has been adopted with success for the synthesis of norcamphor by Komppa,[18] fenchone by Ruzicka,[11] homosantenic acid by Sen Gupta,[20] and homo*apo*-fenchocamphoric acid by Bardhan *et alia*[21]. Lipp condensed ethyl *cyclo*pentanone-3-carboxylate (XXXII) with zinc and

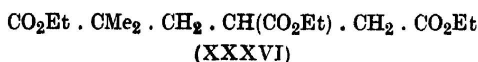
α-bromo-*iso*butyric ester, the resulting hydroxy ester (XXXIII) on dehydration and subsequent reduction yielding camphenic acid (XXXIV)

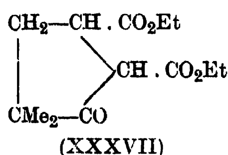


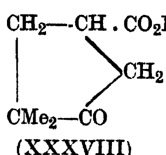
Bardhan, Banerji and Bose's synthesis of homo*apo*fencho-camphoric acid[21] is significant in view of the fact that they had to synthesize the appropriate *cyclo*pentane ester (XXXVIII) for the first time.

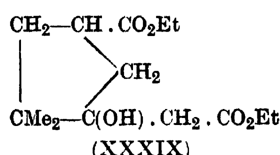
The ester (XXXV) obtained from ethyl αα-dimethylglutarate and ethyl oxalate on condensation with ethylbromoacetate and subsequent hydrolysis and elimination of CO_2 yielded β-methyl pentane-β-δ-ε-tricarboxylic acid, the ethyl ester (XXXVI) of which on cyclization furnished (XXXVII) from which (XXXVIII) was obtained. The hydroxy ester (XXXIX) prepared from the ketonic ester by Reformatsky's reaction gave on dehydration and subsequent reduction the saturated ester from which homo*apo*fenchocamphoric acid (XL) was obtained by hydrolysis.

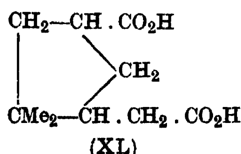






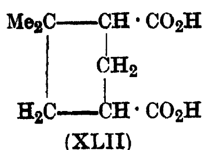


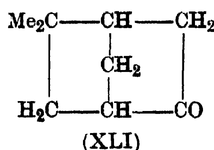


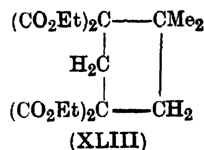


*apo*Fenchocamphoric acid (XLII) obtained by oxidizing β-fenchocamphorone (XLI) has been synthesized by Short.[22] Ethyl disodiopropane-αα'γγ'-tetracarboxylate was condensed with *iso*butylene dibromide to give the ring tetra-ester (XLIII) from which the acid (XLII) was obtained. The reaction is rather anomalous when one considers the experiments of Ipatjew[23] with *iso*butylenedibromide. Further, experiments

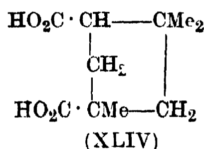
in this laboratory have shown that ethylene dibromide does not condense with ethyl disodiopropane-$\alpha\alpha'\gamma\gamma'$-tetracarboxylate to furnish the corresponding ring tetra-ester.

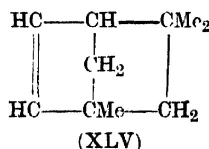

(XLII)

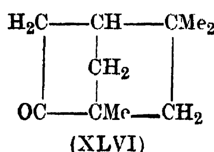

(XLI)

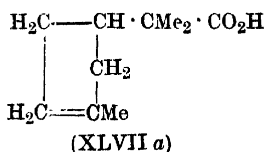

(XLIII)

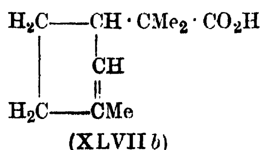
Amongst some of the important degradation products in the compounds of the fenchane series awaiting synthesis, may be mentioned (1) *iso*fenchocamphoric acid (XLIV) obtained by oxidizing δ-fenchene (XLV), (2) *iso*fenchone (XLVI), (3) α-fencholenic acid (XLVII *a* or *b*), and (4) β-fencholenic acid (XLVIII).

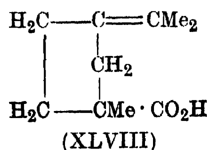

(XLIV)


(XLV)


(XLVI)

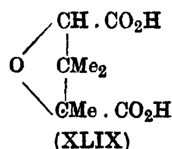

(XLVII *a*)

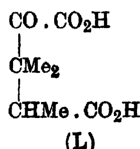

(XLVII *b*)


(XLVIII)

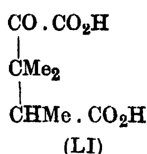
The difficult problem of elucidating the constitution of Balbiano's acid has been resolved by Bardhan's synthesis of the acid.[24]

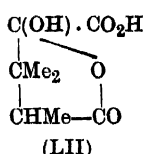
Balbiano[25] had assigned to this acid an oxide ring formula (XLIX) while Mahla and Tiemann[26] preferred the formula (L)

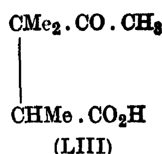

(XLIX)


(L)

Kon, Stevenson and Thorpe[27] considered the liquid or dissolved acid to be an equilibrium mixture of the tautomeric forms (LI) and (LII), proof for the keto-structure being now available through Bardhan's work.

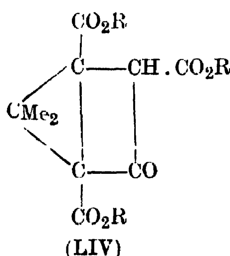


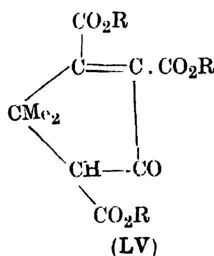




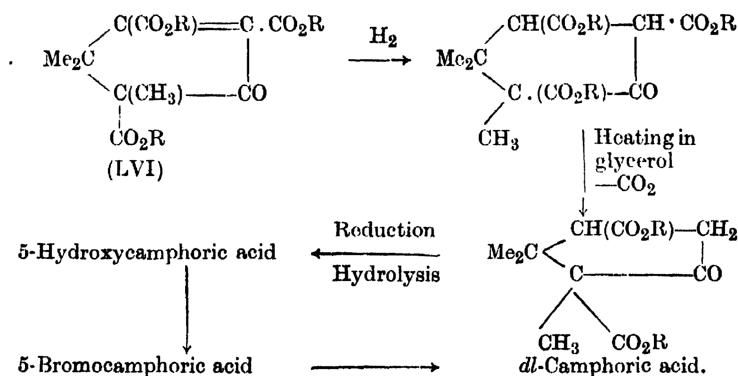
The synthesis of $\alpha\beta\beta$-trisubstituted ketoglutaric acids such as (LIII) is beset with difficulties, and in the present case, Bardhan achieved his synthesis by oxidizing the acetyl group of $\alpha\beta\beta$-trimethyl lævulic acid to -CO-COOH group. $\alpha\beta\beta$-Trimethyllævulic acid was synthesized for the first time and its constitution proved beyond doubt. Bardhan[24] has also suggested a scheme by which Balbiano's acid is derived from camphoric acid.

A new and novel synthesis of camphoric acid is recorded by Toivonen.[28] By the action of sodium malonic ester on $\alpha\alpha'$-dibromo-$\beta\beta$-dimethyl glutaric ester, compound (LIV) or (LV) is obtained.



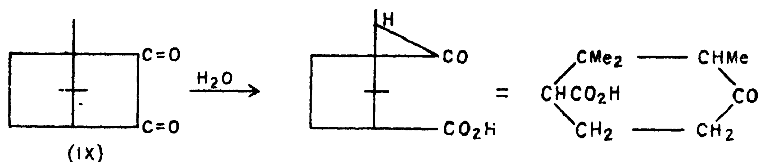


Probably it is (LV) for on methylation with Na and CH_3I, it gives the ester (LVI) which has been converted to camphoric acid by the following series of reactions :—

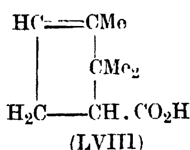


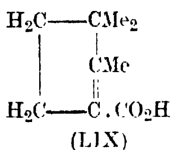
A change related to the Wagner rearrangement but presenting certain peculiarities is undergone by camphorquinone (IX) in the presence of sulphuric acid.[29] The product is a ketonic acid (LVII) in the formation of which one of the *cyclo*pentane rings has been broken and the other enlarged. A synthesis

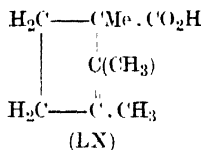
of this ketonic acid would serve as a confirmatory evidence for the mechanism postulated and as such would be of considerable importance.



Although the constitution of α-campholytic acid (LVIII) has been confirmed by the synthesis of Perkin and Thorpe[4] and its remarkable transformation to *iso*lauronolic acid (LIX) is well known,[30] the isomeric laurolenic acid (LX) does not appear to have been synthesized.



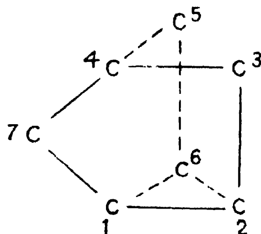




All the known methods of preparation of this compound involve a Wagner rearrangement; but its properties and degradation products point to the formula (LX) proposed by Lapworth.[31]

Tricyclic Terpenes.

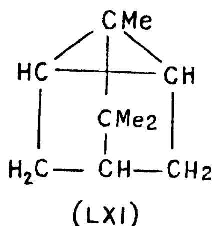
An inspection of the camphor space model reveals that the carbon atoms 2 and 6 are brought together so near in the molecule that the formation of a tricyclic ring with a bond connecting the above carbon atoms would be possible, without involving any great strain in the molecule. In fact, such

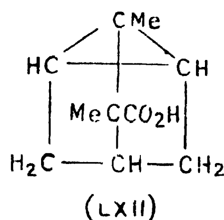


tricyclic compounds are formed without difficulty by the abstraction of halogen[31a] from suitable dihalogenides, by the dehydration[31b] of certain alcohols of the camphane and fenchane series, and also by the breaking up of the diazo compounds[31c] of the camphane series.

Tricyclene $C_{10}H_{16}$ (LXI) which can be regarded as the parent member of this series of compounds does not occur

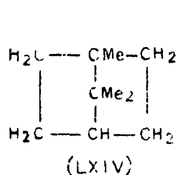
in nature. However, the santalenes (sesquiterpenes) and the santalols, which are the constituents of the East Indian sandal-wood oil contain the tricyclene ring system in their molecules. Further, teresantalic acid (LXII) occurring in sandalwood oil

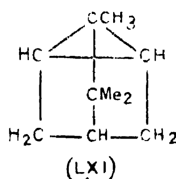


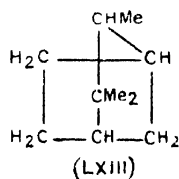


had been converted by Semmler[32] to a hydrocarbon shown by Ruzicka and Stoll[33] to be identical with tricyclene. These compounds are stable to permanganate, but rearrange themselves to compounds of the camphane type when acted on by halogen acids.

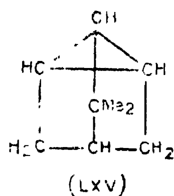
Tricyclene is most easily obtained by oxidizing camphor-hydrazone with HgO.[34] and its most important property seems to be this: On reduction by Sabatier-Senderen's process with nickel catalyst at 180-200° it passes over smoothly into *iso*camphane (LXIII) with the intermediate formation of camphene (III).[34] Zelinsky and Lewina[35] record the formation of camphane (LXIV) when it is passed over platinum black at 155–160°.

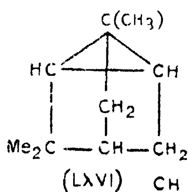


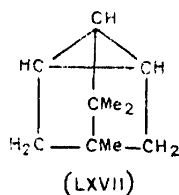


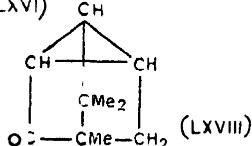


*apo*Cyclene (LXV), *cyclo*fenchene (LXVI), and epicyclene (LXVII) are other important members of this group, the last









being obtained by treating the hydrazone of 3 : 5-*cyclo*camphanone (LXVIII) with sodium alcoholate.[36]

Mechanism of the Wagner Rearrangement.[37]

The cases of Wagner rearrangement known are very numerous and the publications dealing with the mechanism of the change, for which Meerwein is mainly responsible, have received very careful attention of chemists. No one theory has been found to satisfy all the requirements and peculiarities of the change.

The intermediate *cyclo*propane ring-formation theory which is upheld notably by Ruzicka[38] does not seem to be supported by a large number of facts, and definite evidence has been brought against such a theory by the work of Meerwein.[34] A second hypothesis has been produced in several forms involving partial valencies (Robinson[39]), free valencies (Tiffeneau[40]), or ions (Meerwein and Wortmann[41]) and if one takes into consideration as Ingold says, 'that the production of free valencies and ions may be merely different manifestations of the same structural condition, this condition depending on a peculiar distribution of residual affinities', these different views are not so antagonistic to each other as they might appear. In Prof. Ingold's words 'It therefore seems possible that, although in the great majority of cases the mutual attraction of the two parts of the molecule ultimately eliminated may cause an altered distribution of affinity and the consequent migration of a group, there may be special structures in which the natural distribution of affinity (apart from any tendency towards an elimination) is such as to loosen one of the attached groups, and give rise under suitable conditions to isomeric change dependent on the formation of a free valency or ion'.

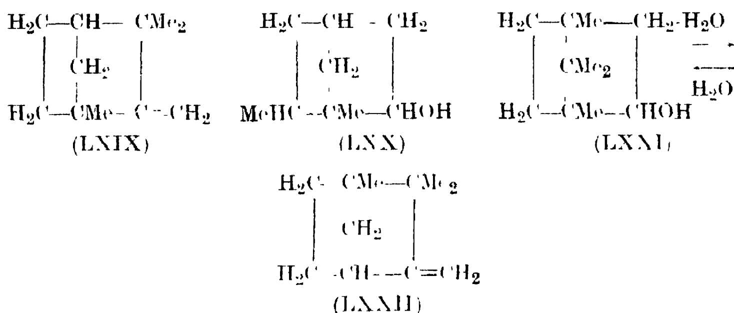
Cases are known where the Wagner change may occur without any elimination and where there is little chance of water being added and subsequently removed. In these instances, independent evidence is not wanting, for the possibility of ionization is facilitated by the use of a dissociating solvent. These facts certainly point to the ionic hypothesis.

As matters stand, the Robinson theory has been given an electronic interpretation and Lapworth's development which takes into account the directing influence of ions in solution seems to afford a quite satisfactory explanation of the change.

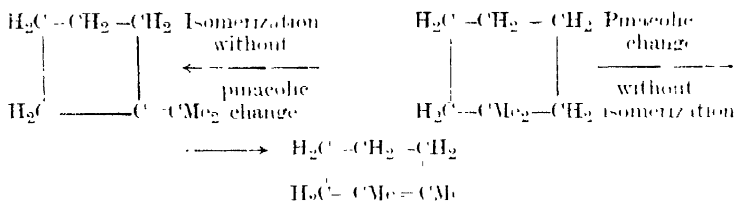
The Nametkin Rearrangement.

Although it is usual to assume interaction exclusively between carbon atoms in positions 2 and 6 during the Wagner rearrangement, it is now shown by the recent work of Nametkin and Brussowa,[42] and Nametkin, Kitschin, and Kursanoff[43] (and

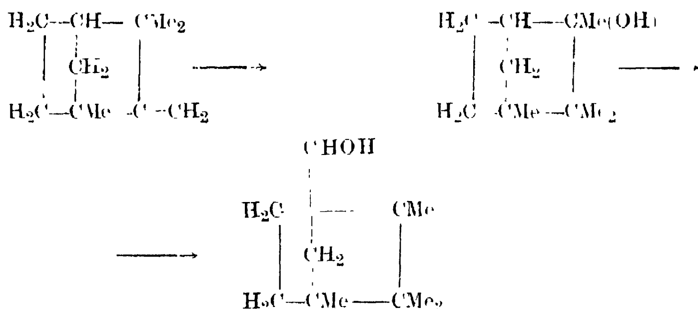
independently confirmed by later work of Bredt,[44] Bredt-Savelsberg and Buchkremer[45]) that this is preceded in certain cases by a pinacoline rearrangement without ring-isomerization. For instance, Nametkin and Brussowa find that α-methylcamphene (LXIX) is hydrated to a methyl*iso*borneol which is not the 6-methyl-compound (LXX) as expected by a Wagner rearrangement but the 4-methyl compound (LXXI). The latter on dehydration furnishes β-methylcamphene (LXXII) along with α- methylcamphene.



The explanation offered is that 'even as dehydration of 2 2-dimethyl*cyclo*hexanol can take place *without* change of ring structure but is then accompanied by the wandering of a methyl group (Meerwein), so the reverse process also can take place'.

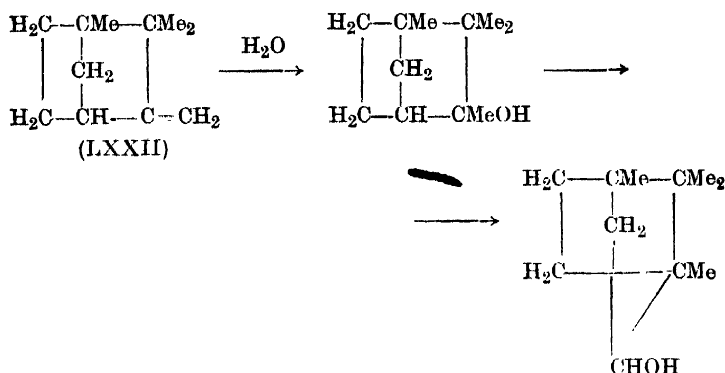


Thus α-methylcamphene is hydrated in the following way :—



In the case of β-methylcamphene (LXXII) there is no need for the pinacolic change due to the presence of a -CH-group adjacent

to the $C{=}CH_2$. The intermediate camphene hydrate is formed by the simple addition of water at the double bond.



It might be assumed that in the case of camphene both processes would lead to the same final product, but Houben and Pfankuch[46] have indicated the converse. Actually, the camphenes obtained from, say, *iso*borneol according to the two processes would be the mirror images of each other, owing to the two rings not being in the same plane. Also, different products are to be expected according as the methyl and hydroxyl group which are interchanged are *cis* or *trans* to one another, with changes in the sign of rotation. Houben has illustrated this aspect by a number of investigations.[16, 47]

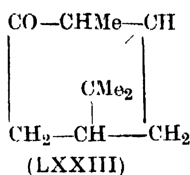
Physiological Action of Camphor Compounds.[48]

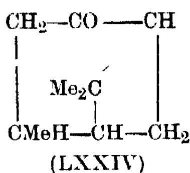
The medicinal use of camphor is due to its exercising a stimulative action (followed later by a sedative action) alike on the heart and the skin. As regards the comparative activity of the various stereoisomeric forms of camphor, the *laevo* form is most active, and the synthetic variety has a more toxic action on the heart than the *dextro*-form.[49] Further, the *laevo* form is the stronger anthelmintic.[50]

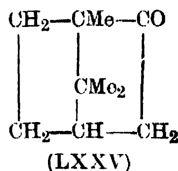
The great practical obstacle to the use of camphor in medicine is the fact that it is insoluble in water and is therefore uncertain of absorption.

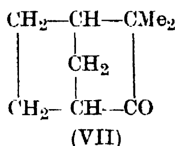
Attempts to correlate the chemical constitution of the various camphor analogues and derivatives with their physiological activities have proved quite unavailing, although much interesting information has been disclosed.

Siegl[51] finds that of the three compounds pinocamphone (LXXIII), verbanone (LXXIV), and camphor (LXXV), pinocamphone is much more poisonous than camphor especially with regard to its action on heart. Verbanone lies between camphor and pinocamphone in its activity.


(LXXIII)

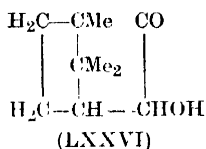

(LXXIV)

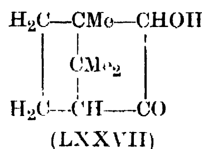

(LXXV)


(VII)

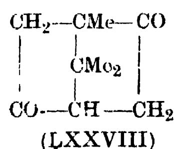
Camphenilone (VII) resembles camphor in its activity. The conversion of camphor into such derivatives as aminocamphor, dihydrocamphenehydrazine, and dicamphenepyrazine considerably raises the toxicity and paralytic activity. Bromonitrocamphor, camphorquinone, and methyldicamphoryl carbinol are more paralyzing than the parent substance. Strangely enough, *epi*camphor possesses very little of the activity of camphor.

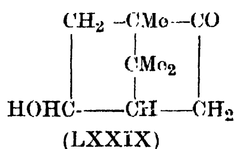
The most interesting group of camphor derivatives are the hydroxy compounds, but they again defy all attempts at a correlation between physiological activity and chemical structure. Hydroxycamphor (LXXVI) is as active as camphor but when the hydroxyl and carbonyl groups are interchanged as in the compound campherol (LXXVII) the activity disappears.

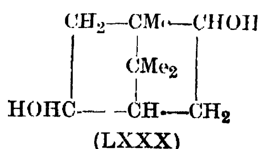

(LXXVI)


(LXXVII)

p-Diketocamphor (LXXVIII) resembles camphor in its activity, this being maintained when one of the keto-groups is reduced to the carbinol as in (LXXIX); but when both groups are reduced to the carbinol as in *p*-dihydroxycamphor (LXXX) the activity disappears.


(LXXVIII)

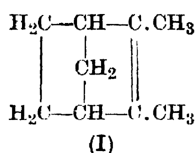

(LXXIX)


(LXXX)

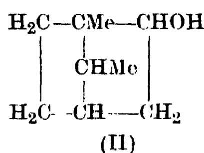
These results, together with a consideration of the modern camphor substitutes in which no logical relation in chemical structure can be traced, show that at present it is useless to attempt a correlation between chemical structure of these compounds and their physiological activity.

Santane Series.

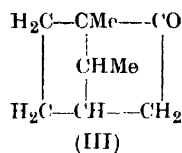
Knowledge of the santane series is recent. The members form a class by themselves containing as they do nine carbon atoms in the molecule and not ten as is the case with all other bicyclic terpenes. Its occurrence in nature has been adduced as an exception to the isoprene unit theory of the structure of terpenes by Mitter[1] (cf. Simonsen's comment in his book 'The Terpenes', Vol. II, p. 3). The phenomenon of Wagner rearrangement so well known among members of the pinane and camphane series is also manifested by some members of this group, the formation of santene from camphenilone by Hintikka and Komppa[2] being a typical example. Only three members of the santane series have till now been recognized in nature, namely santene, santenol and *l*-santenone. Santene C_9H_{14} (I) is a bicyclic hydrocarbon isolated for the first time by Müller[3] from the East Indian Sandalwood oil and discovered later on by Aschan[4] as a constituent of the ill-smelling oil in pine needle and other essential oils. The synthesis of this substance has been achieved and is mentioned in the sequel.



(I)

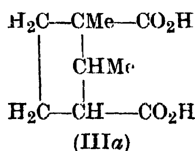


(II)

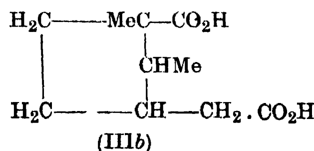


(III)

The presence of santenol $C_9H_{16}O$ (II) a bicyclic secondary alcohol and santenone $C_9H_{14}O$ (III) both resembling camphor in odour[5] was discovered in the East Indian Sandalwood oil in 1910[5] named 'santenone alcohol' and their constitution established from a study of their oxidation products. When oxidized with chromic acid santenol yields santenone. Komppa[6] synthesized santenic acid and *iso*santenic acid (III*a*) starting from β-monomethyl glutaric ester by his well-known method of synthesizing camphoric acid. Sen Gupta[7] in the course of his work on the synthesis of santenone, has described a synthesis of homosantenic acid (III*b*)



(III*a*)

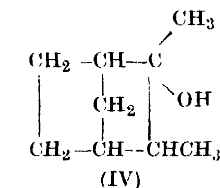


(III*b*)

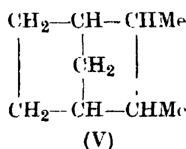
Although several isomeric santenols are described, not much of systematic work appears to have been done towards establishing their inter-relationship. No optically active santenol occurring in nature or prepared artificially appear to have been described, though possible theoretically, the slight activity of

the santenol prepared from santene being ascribed to the presence of impurities. Santenone gives with potassium permanganate the monocyclic dibasic santenic acid, and formation of hydroxymethylene and benzylidene derivatives points to the presence of a CH_2 group adjacent to the carbonyl group. Furthermore, the synthesis of this substance, although by an indirect method, i.e., by the oxidation of santene, confirms the structure III. The close chemical and structural relationship of this substance with camphor calls for a fuller and detailed investigation of the reactions of santenone which perhaps will not be possible until a good source of this is discovered either in nature, or until it can be prepared in good yield artificially. Aschan[8] has recently prepared two oximes and two semicarbazones from the crude santenone and regards them as stereo-isomerides. Semmler and Bartelt[9] prepared the inactive form of santenone by oxidation of π-norborneol with chromic acid and called the product π-norcamphor. Later Aschan[10] prepared this by oxidizing santene with chromic acid.

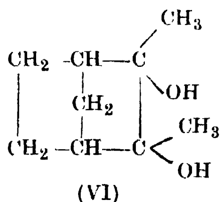
A few isomeric santenols, santene hydrate, *i*-santenone, santane, santene glycol, santenic acid, etc., have been prepared. Semmler and Bartelt[9] prepared π-norborneol (m.p. 68–70°) from teresentalic acid and π-nor*iso*borneol (m.p. 91-92°) from santenone; Komppa[11] prepared π-nor*iso*borneol (m.p. 97-98°) by the hydration of santene according to the Bertram-Walbaum method. To the very difficultly oxidisable santene hydrate (IV), Aschan (Simonsen, 'The Terpenes', Vol. II, p. 216) has suggested the name β-santenol and prepared it by treating santene with milk of lime. Diels and Alder[12] have prepared an isomeric hydrate (?) from 6-methylnorcamphor with magnesium methyl iodide and named it γ-santenol; they have shown that β- and γ-santenols are *cis*- *trans*-isomerides.



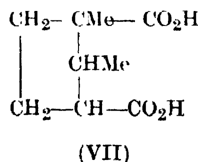
(IV)



(V)



(VI)

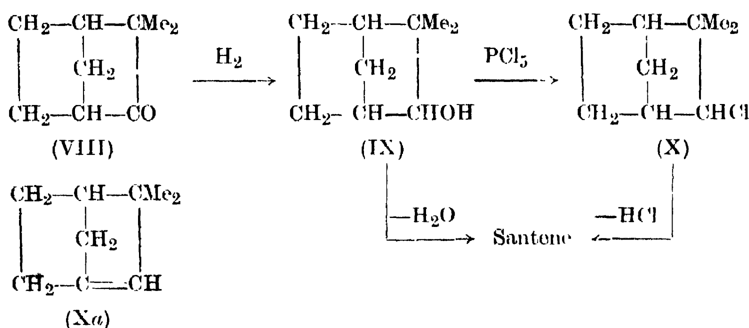


(VII)

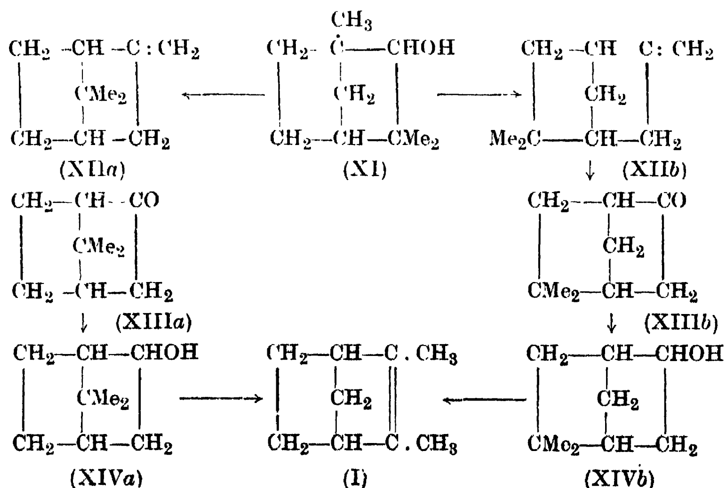
Santane (V), the saturated liquid parent hydrocarbon of this series, has been prepared by Deussen[13] by reducing santene

with hydrogen in presence of palladium catalyst. Semmler and Bartelt prepared santene glycol (VI) by oxidizing santene with $KMnO_4$. Aschan[10] and Komppa and Hintikka[14] obtained santenic acid (VII) by the oxidation of santenol with alkaline potassium permanganate. The existence of a number of isomeric santenols foretells the presence of a number of isomeric santenic acids. Enkvist[15] has already proved the existence of geometrical isomerism in santenic acids.

Of the various methods employed for the preparation of santene, two involve Wagner rearrangement. Hintikka and Komppa[16] synthesized it from camphenilone (VIII) *via*, camphenilol (IX) and camphenilyl chloride (X); the latter gave santene on removal of HCl, although it was originally regarded by the authors themselves as camphenilene (X*a*). Meerwein[17] suggested its identity with santene on the ground of (X*a*) contravening Bredt's law, proved subsequently to be correct by Komppa and Hintika.[14]

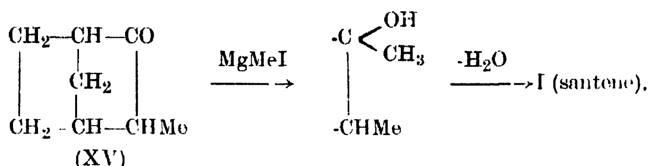


Ruzicka and Liebls' method[18] is as follows: Fenchyl alcohol (XI) on dehydration gives α- and β-fenchenes (XII*a*, XII*b*)

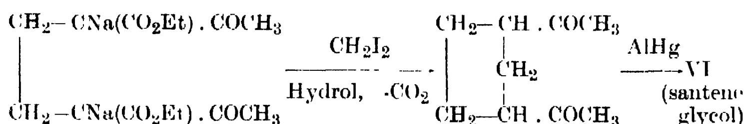


which on ozonolysis yield the corresponding α- and β-fenchocamphorones (XIIIa, XIIIb). These on reduction give α- and β-fenchocamphorols (XIVa, XIVb) which on dehydration accompanied by Wagner rearrangement yield santene.

Diels and Alder[12] were the first to achieve a direct synthesis of santene from methylnorcamphor (XV) as follows :

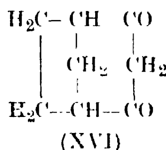


More recently Mohunta and Ray[19] have achieved another direct synthesis of santene glycol starting from diethyl diacetyladipate as follows :



Work on the synthesis of santene glycol and santene planned exactly according to the above scheme was in progress in our laboratory[20] and was abandoned when Mohunta and Roy's paper came to our notice in October, 1934.

The interesting bicyclic diketone (XVI) has been obtained by Guha and Ranganathan[21] starting from *cyclo*pentane 1 : 3-dicarboxylic acid *via* the anhydride, acid ester, acid chloride ester, and ketone ester, the ketonic acid corresponding to the last ester being identical with Semmler and Bartelt's ketonic acid obtained from santene.

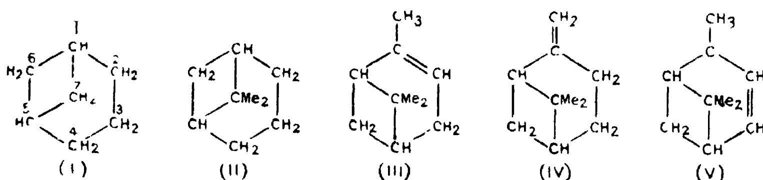


Work on the synthesis of compounds of this group is under progress in this laboratory by the condensation of suitable dihalogen compounds, e.g. sym-dimethyl ethylenebromide on the Na-derivative of *cyclo*pentanone-2 : 5-dicarboxylic ester (cf. Guha and Seshadriengar, *Current Science*, 1934, **3**, 21).

Pinane Series.

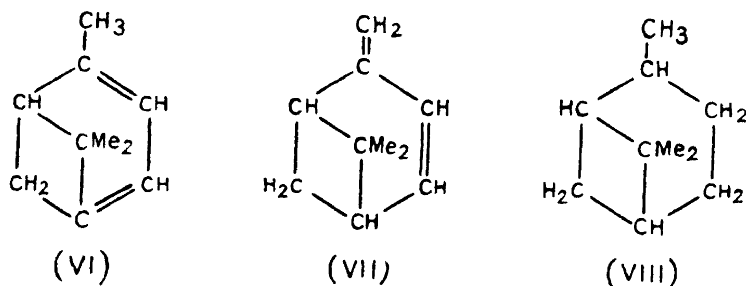
Both from theoretical and practical point of view, the position of pinene and its derivatives in the chemistry of the terpenes is unique. The wide distribution in nature of these

bicyclic hydrocarbons containing a *cyclo*butane ring is obviously not in conformity with expectation, since according to theory and experience the four-membered carbon rings are the most difficult to construct,[1] though the advent of the valency deflection hypothesis has shown that the *gem*-dimethyl group, which is invariably present in the *cyclo*butane ring in the naturally occurring compounds, stabilises and also facilitates the easy formation of the ring.[2] The whole group of compounds of the pinane series can be supposed to be derived from the hypothetical mother compounds 'norpinane'[3] (I), [*bicyclo*-(1 : 1 : 3)-heptane] and 'nopinane' (II)[3] [7 : 7 or 6 : 6-dimethyl*bicyclo*-(1 : 1 : 3)-heptane], none of which has been obtained synthetically as yet.



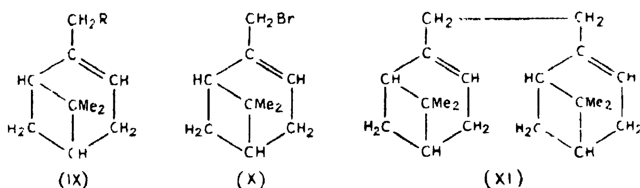
Natural Hydrocarbons and other substances obtained Artificially.

α-Pinene (III), is the most important of all the terpenes and most widely distributed in nature, as evident from its occurring in 374 oils[4] according to the last count in 1931. Very closely related to this, is the structural isomer *β-pinene* (IV), which also occurs in the majority of oils accompanying α-pinene, and the relation between the two has been established by the conversion of β-pinene into α-pinene.[5] the reverse change remaining uneffected yet. The constitution of these compounds has been settled by the brilliant researches of Wagner, Baeyer, Semmler, and Tiemann. *δ-Pinene* (V), though not occurring in nature, has been prepared by the decomposition of (i) trimethylpinocamphylamine hydrochloride,[6] (ii) the xanthates of verbanol[7] [8] and pinocampheol,[9] and (iii) by exhaustive methylation of verbanylamine.[10] Another hydrocarbon of some interest obtained only artificially by the dehydration of verbenol is *verbenene*[11] which exhibits the properties of a conjugated system



of two double bonds, gives on reduction dihydroverbenene which has got a pinene like odour and is oxidized to *cis*-norpinic acid. Since the formula of Blumann and Zeitschel [11] (VI) for verbenene is not in conformity with Bredt's rule and cannot explain the production of norpinic acid, Ruzicka and Poutalti [6] have suggested the structure (VII) for it. According to Ruzicka's formula, dihydroverbenene should be α-pinene or a stereoisomer, and this requires confirmation.

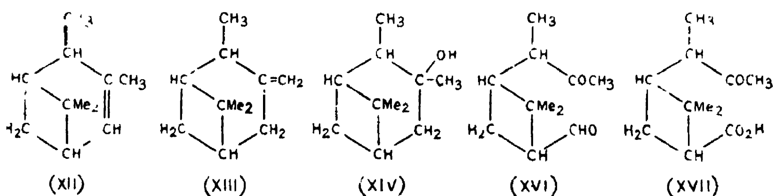
Pinane (VIII), the completely reduced member of this series, though not found in nature, has been obtained by (i) catalytic hydrogenation of α- and β-pinenes,[12] (ii) by the reduction of the hydrazone and semicarbazone of pinocamphone by Kishner's process [13, 14] and (iii) by the action of sodium ethylate on verbanone hydrazone.[15] Lipp [12] has clearly shown that two



forms of pinane (*cis* and *trans*) exist (though no account of the conversion of each into the other is given) which is in accordance with the requirements of theory. Nametkin [14] showed the pinane obtained by reduction of pinene, to be different from that derived from pinocamphone, and hence called the latter pinocamphane. Lipp has demonstrated the remarkable stability of pinane to oxidizing agents and mineral acids.

Rupe and Heritier [16] obtained a series of *homologues* of pinene of type (IX), where R is methyl, propyl, phenyl, benzyl, phenylethyl, phenylpropyl, phenylethylenyl, and myrtenyl, by treating myrtenyl bromide (X) with MgRI. Myrtenyl bromide with magnesium gave *dimyrtenyl* (XI).

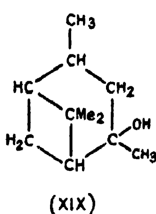
Two isomeric methylpinenes, *endocyclic methylpinene* (XII) and *semicyclic methylpinene* (XIII) have been obtained by



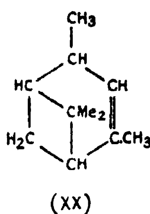
Hasselstrom [17] by the dehydration of methylpinocampheol (XIV) with hydrogen potassium sulphate derived from pinocamphone by means of magnesium methyl iodide. The constitution of the two compounds was established by ozonization,

whereby XIII gave pinocamphone, while (XII) gave a mixture of the ketone aldehyde (XVI) and the ketonic acid (XVII).

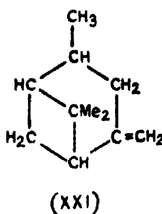
By the dehydration of methylverbanol (XIX) an isomeric hydrocarbon 'homopinene' or 'homoverbanene' has been obtained by Wienhaus and Schumm[15] which can be represented



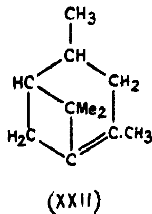
(XIX)



(XX)



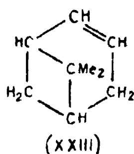
(XXI)



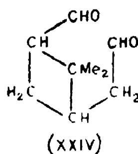
(XXII)

by (XX) or (XXI), the other possible structure (XXII) violating Bredt's rule. Oxidation of this will decide between the two structures.

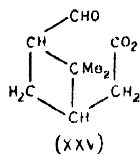
The last important hydrocarbon of this series is 'apo*pinene*' (Δ^2-nopinane) (XXIII) obtained by Komppa and Hasselstrom,[18] by the dehydration of either of the two stereoisomeric nopinols. The constitution of the hydrocarbon was settled by ozonizing it to the dialdehyde of pinic acid XXIV and the aldehydo-acids XXV and XXVI, the last two giving norpinic acid on further oxidation.



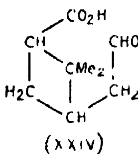
(XXIII)



(XXIV)



(XXV)

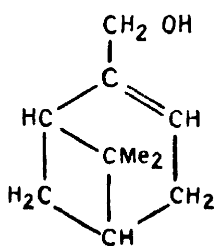


(XXIV)

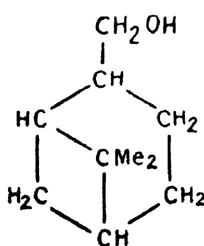
Alcohols.

Of the alcohols, pinocampheol is of interest in that there are two isomers known (natural, *l*-variety, m.p. 67-68° ; synthetic *l*-variety, m.p. 56-57°) as is expected from theory, though the stereoisomerism has not been thoroughly studied and the xanthate of this, similarly as that of verbanol, gives on decomposition a mixture of α- and δ-pinenes.[9] Dupont, Zacharewics, and Dulou[19] have very recently obtained myrtenol (XXVII) by oxidizing α-pinene with selenium dioxide. Either myrtenol or myrtenal (XXXI) by catalytic hydrogenation gives iso-*myrtanol* (XXVIII)[20] whereas, the stereoisomeric myrtanol can be obtained by reducing myrtenol with sodium. That the former is the *cis* and the latter the *trans* isomer has been supported by the study of the Raman spectra of these compounds.

Methylnopinol (XXIX) is obtained in two forms (i)[12] by the oxidation of pinane with permanganate (m.p. 79°) and (ii)[21] by the action of magnesium methyl iodide on nopinone

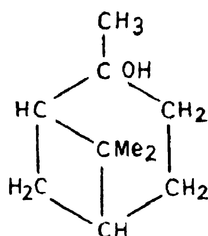


(XXVII)

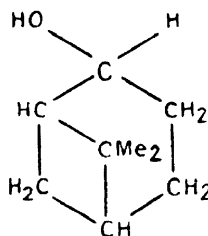


(XXVIII)

(m.p. 58-59°). The latter could not be dehydrated to a pinene by Wallach. Similarly nopinone on reduction gives two *nopinols* (XXX)[22] (the α- being a solid and the β- a liquid), the configurations of which have not been thoroughly studied.



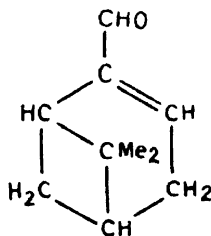
(XXIX)



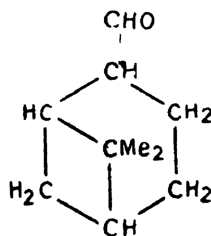
(XXX)

Aldehydes.

Myrtenal (XXXI), the only aldehyde of this series known to occur in nature, has also been obtained by oxidation of the corresponding alcohol myrtenol (XXVII)[19] [23] and from α-pinene by oxidation with selenium dioxide.[19] By catalytic hydrogenation, myrtenal gives *dihydromyrtenal* or *myrtanal* (XXXII), obtainable also from β-pinene oxide[24] by distillation. Myrtenal on oxidation gives an excellent yield of pinic acid.[19]



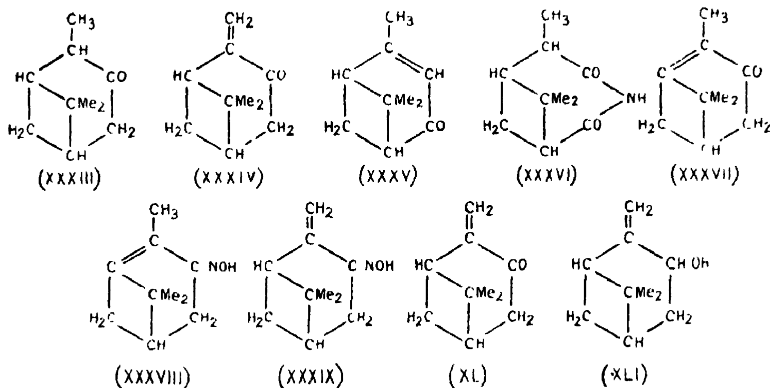
(XXXI)



(XXXII)

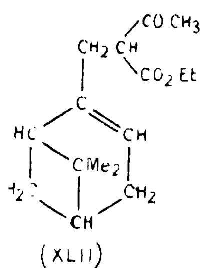
Ketones and Acids.

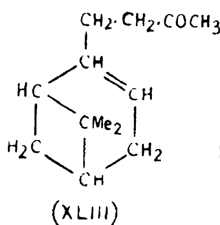
The more important ketones of this group are (i) the naturally occurring *pinocamphone* (XXXIII) partially synthesized by Ruzicka [25] from pinonic acid, (ii) *pinocarvone* [26] (XXXIV) obtained only from β-pinene by autoxidation, and (iii) another natural product verbenone (XXXV) obtained from α-pinene by autoxidation and by catalytic oxidation.[19, 7] *Verbanone* is obtained by the catalytic hydrogenation of verbenone,[7] and also by the oxidation of dihydroverbenol.[11] *Iso*nitrosoverbanone obtained by the action of amyl nitrite on verbanone, undergoes the Beckmann change giving the imide (XXXVI) which with alkali gives the two isomeric monoamides of pinocamphoic acid.[7] To *carvopinone* derived from nitrosopinene with oxalic acid,[27] Wallach had assigned the constitution (XXXVII) assuming nitrosopinene to be (XXXVIII) in violation of Bredt's rule.

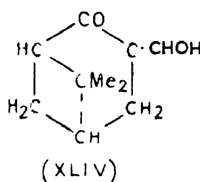


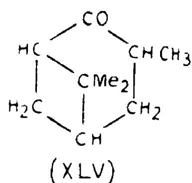
Since Ruzicka and Trebler [28] have shown that nitrosopinene is XXXIX, carvopinone (in absence of any isomerization during hydrolysis) should be represented by XL, whence it becomes a stereoisomer of pinocarvone. Confirmation of this is absolutely necessary. Similarly pinocarvol should be represented by XLI, as an isomer of pinocarveol, the isomerism being probably due to the arrangement of the atoms in different planes.

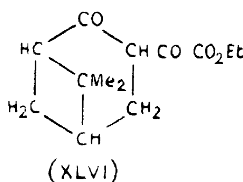
Myrtenyl bromide on treatment with acetoacetic ester gives ethyl myrtenylacetoacetate (XLII) which on hydrolysis gives *homomyrtenylmethylketone* (XLIII).[16] Kotz and Lemien [29] on methylating nopinone obtained oxymethylenenopinone (XLIV) which on catalytic hydrogenation gives *methylnopinone* (XLV), a structural isomer of verbenone and pinocamphone. When nopinone is condensed with oxalic ester, nopinone oxalester (XLVI) is obtained, the sodium salt of which on being heated for several days with methyl iodide gives a small quantity of methylnopinone. Nopinonecarboxylic ester (XLVII) could also be obtained from XLVI.

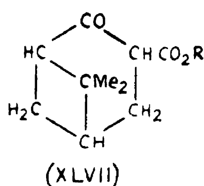






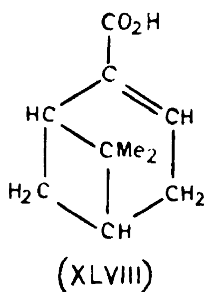


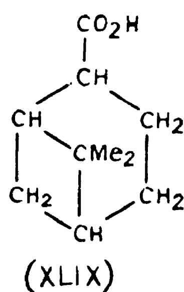




No acid of this group is known to occur in nature.

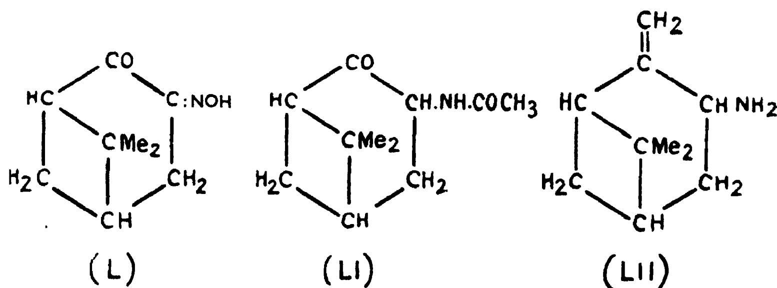
Nopinic acid has been obtained by the oxidation of β-pinene with permanganate.[30]





d-Myrtenaloxime when digested with acetic anhydride gives the nitrile which on hydrolysis gives *myrtenic acid* (XLVIII) giving *dihydromyrtenic acid* (XLIX)[19] on reduction.

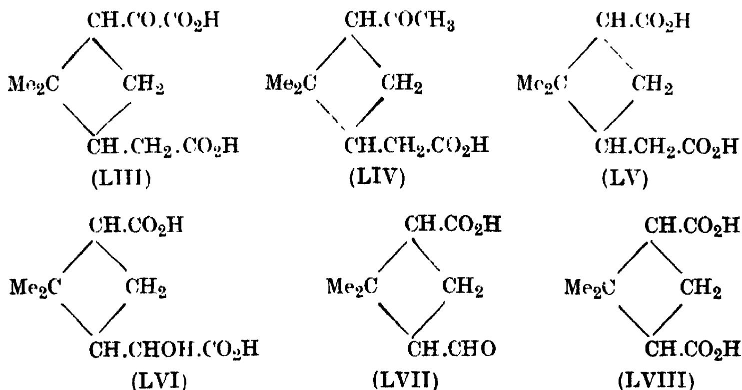
The constitution of nitrosopinene was a subject of considerable controversy, but has been settled by Ruzicka and Trebler[25] as follows: On reduction with zinc dust and acetic acid nitrosopinene gave pinylamine which on treatment with nitrous acid gave pinocarveol, giving pinocarvone on oxidation; all these are shown to be members of the β pinene group and nitrosopinene represented by formula (XXXIX).



Further support has been obtained by ozonizing nitrosopinene and acetylpinylamine, yielding respectively *iso*nitrosonopinone (L) and acetylaminonopinone (LI) with the formation of formaldehyde in each case. Pinocarvone gives an oxime not identical with nitrosopinene, and its reduction gives pinocarvylamine (LII) not identical with pinylamine. Ruzicka has explained these observations as due to the differences in the planar arrangements of the atoms in the molecule, dealt with later.

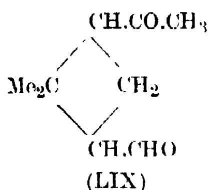
Important Degradation Products.

The classical researches of Baeyer on the constitution of pinene resulted in the isolation of a series of important acids, viz., pinoylformic acid (LIII), pinonic acid (LIV), pinic acid (LV), hydroxypinic acid (LVI), norpinaldehyde (LVII), and norpinic acid (LVIII) the last being very stable, could not be further degraded, supporting thereby the general view that though the formation of a *cyclo*butane ring is difficult, the ring once formed has considerable stability. It is of interest to note that none of these acids has been synthesized excepting norpinic acid the synthesis of which was effected only in 1929 by Kerr.[81] Though *cyclo*butane and methyl*cyclo*butane are known for long, dimethyl*cyclo*butane, which can be considered to be the mother compound

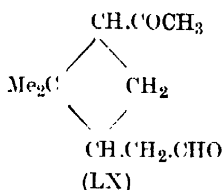


of these acids, is yet to be synthesized. The synthesis of pinonic acid will be of great interest since it will amount to a total synthesis of α- and δ-pinenes, Ruzicka having synthesized them starting from pinonic acid.

Slawinski, Piliczewski, and Zacharewics [32] oxidized an acetone solution of pinene (with permanganate) to a neutral product, from which they were able to isolate pinene glycol, pinononaldehyde (LIX) and a keto-alcohol. When ozonized oxygen is passed through β-pinene in chloroform at 0°, an ozonide $C_{10}H_{16}O_3$ is formed and when shaken with 5 per cent. KOH or subjected to steam distillation yields nopinone and an unidentified product m.p. 125-26°.[33] The experiment of Schmidt [34] is of great importance, as contrary to the statement of Simonsen [35] it proves the presence of the *cyclo*butane ring in β-pinene. By ozonizing β-pinene he obtained nopinone and another product $C_{10}H_{16}O_2$ (α_D-13.8°) (disemicarbazone) which on oxidation with 3 per cent. permanganate gave pinonic acid. This product is the corresponding aldehyde (LX).



(LIX)



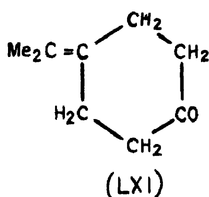
(LX)

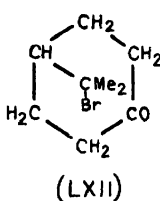
Synthesis in the Pinane Series.

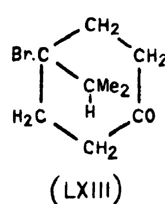
Although pinene is known to occur very widely, and its chemistry has been thoroughly investigated by the brilliant researches of Wallach, Baeyer, and others, it is indeed very surprising that no total synthesis of even one bicyclic derivative in this group has been effected.

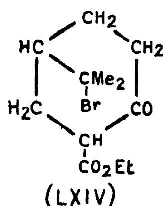
It has been repeatedly observed that the methods of preparing five, six and even three membered ring compounds fail either partly or wholly when applied to the *cyclo*butane compounds The failure of Perkin and Simonsen [36] to synthesize nopinone by a method apparently more congenial than any other conceivable is really very significant. 4-*iso*Propylidene-*cyclo*hexanone (LXI) on treatment with hydrogen bromide gives an addition product (LXII), the formation of the other possible isomer (LXIII) being argued as out of question, not by any rigorous experimental proof, but by analogy with other cases of addition of HBr. From the bromo-compound although alcoholic potash eliminates hydrogen bromide no trace of nopinone could be detected in the product. Sodium ı-β-bromo-*iso*propyl*cyclo*hexanone-2-carboxylate (LXIV) when digested in alcoholic solution, loses NaBr without the formation of the expected nopinone derivative. These two observations clearly

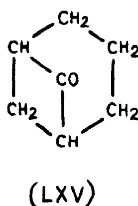
show that the formation of the *cyclo*butane ring from a *cyclo*hexane ring by 1 : 3-bridging is not possible. This observation is confirmed by the experiment of Stark [37] who by distilling the calcium salt of hexahydro*iso*phthalic acid claimed to have produced 'demethylated pinone' (LXV), which proved only to be methyl*cyclo*hexenone (LXVI) obtained by Kotz and Steinhorst.[38]

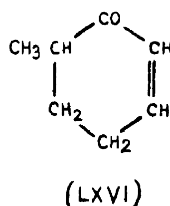

(LXI)


(LXII)

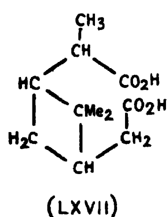

(LXIII)

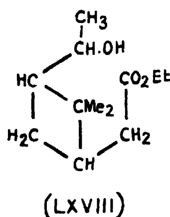

(LXIV)

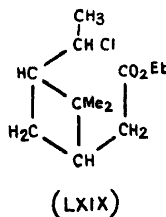

(LXV)

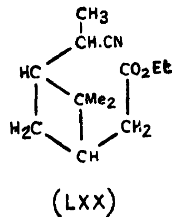

(LXVI)

Starting from pinonic acid, Ruzicka,[6, 25, 39] has effected the synthesis of α- and δ-pinenes, although his initial attempts to

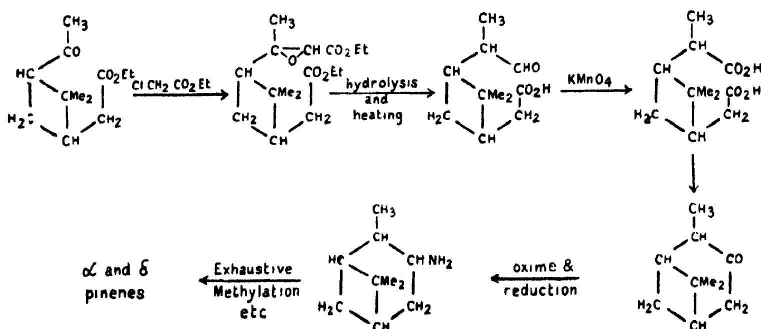

(LXVII)


(LXVIII)


(LXIX)

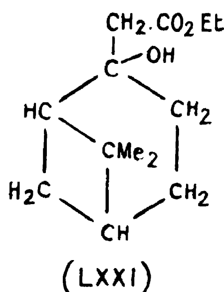

(LXX)

prepare homopinocamphoic acid (LXVII) met with no success. Pinonic ester on catalytic hydrogenation gave the hydroxy

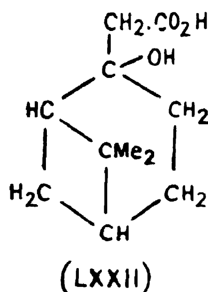


compound (LXVIII), which with PCl_5 gave the corresponding chlorocompound (LXIX) conversion of which into (LXVII) through the nitrile (LXX) was not possible, the yield of the nitrile being very poor. Another attempt, starting with pinonic acid cyanhydrin also failed, but the method as indicated above proved successful, leading to the partial synthesis of pinocamphone, α-pinene and δ-pinene.

β-Pinene has been synthesized by Wallach[40] from nopinone *via* ethyl nopinolacetate (LXXI) the corresponding acid (LXXII) on dehydration by hydrogen potassium sulphate furnishing β-pinene. Since α-pinene can be obtained from β-pinene, the partial synthesis of the former may also be regarded as achieved.

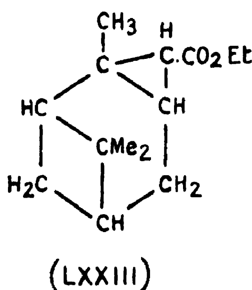


(LXXI)

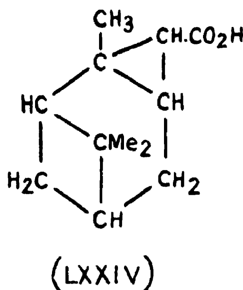


(LXXII)

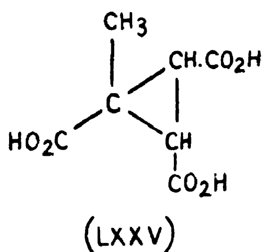
Buchner and Rehorst[41] condensed α-pinene with ethyl diazo acetate and obtained a very interesting tricyclic ester (LXXIII). The constitution of the corresponding acid (LXXIV) was



(LXXIII)



(LXXIV)

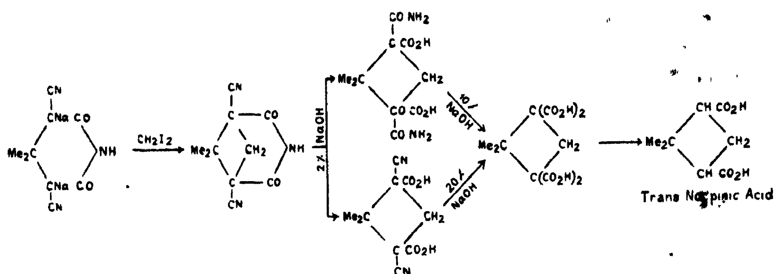


(LXXV)

settled by its being oxidized to terebic acid and methyl*cyclo*propane-1 : 2 : 3-tricarboxylic acid (LXXV). The formation of the *cyclo*propane ring as a third ring is very interesting, showing clearly that the pinene is very unstrained allowing the easy construction of a third ring. This accounts for the existence of such tricyclic rings in nature.

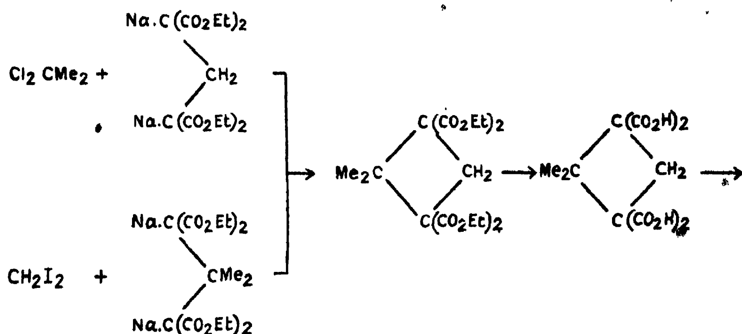
The difficulties involved in the synthesis of *cyclo*butane rings are well known and account for the fact that dimethyl*cyclo*butane and the series of degradation products of pinene have not been synthesized yet. The synthesis of norpinic acid

was achieved only in 1929 by Kerr[31] starting from Guareschi imide as follows :



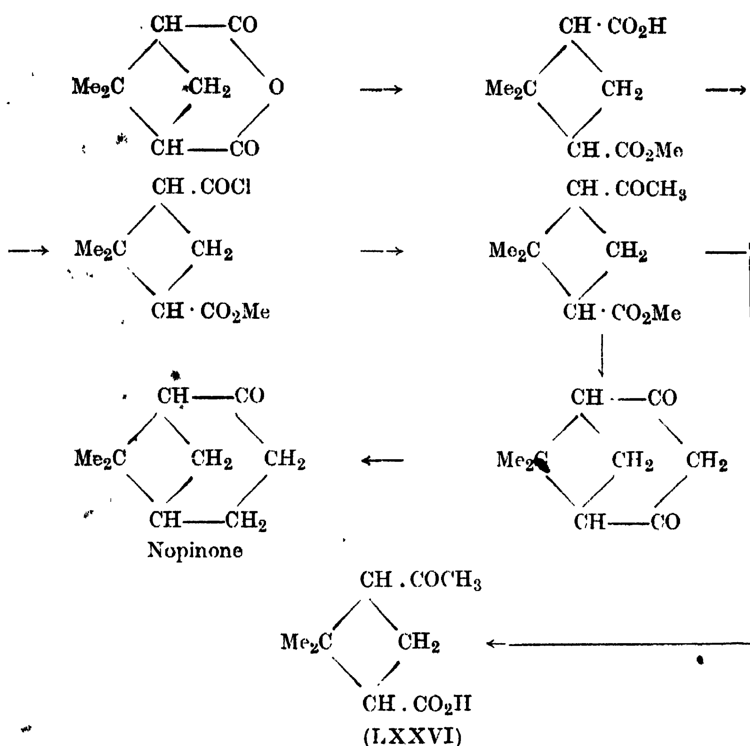
Shoppe and Simonsen[42] converted this synthetic *trans*-acid into the *cis*-variety and thus proved the identity with the product obtained by degrading pinene.

The same *trans*-acid has been synthesized by Gaind and Guha[43] by the following two methods :

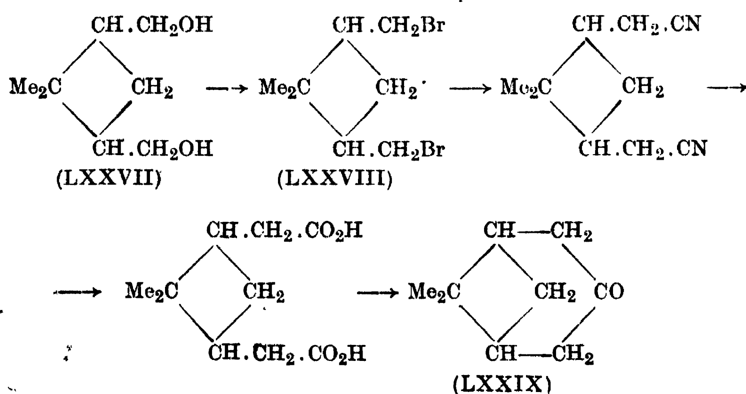


Since the construction of a bridged *cyclo*butane ring starting from a *cyclo*hexane derivative has not been feasible till now (cf. Mayurnathan and Guha),[44] the construction of a 1 : 3-bridged *cyclo*hexane ring starting from a *cyclo*butane should engage the attention of synthetic workers in this field and now that *cis*-norpinic acid can be obtained synthetically, a series of synthetic attempts have been launched by Guha and Ganapathi[45] with the object of synthesizing pinene and its derivatives starting from *cis*-norpinic acid. Ketonopinone (LXXVI) has now been synthesized as is indicated below, which on reduction is expected to yield ' nopinone ' and also ' nopinane '.

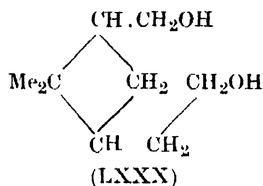
The synthesis of ketonopinone is the first total synthesis of a bicyclic compound in the pinane series. In this scheme it can be seen that pinononic acid has been synthesized incidentally. An alternative method of synthesizing nopinone from *cis*-norpinic anhydride is in progress following that of Lapworth and Royle[46] for their synthesis of homocamphor from camphoric anhydride. The synthesis of an isomer of nopinone is in progress



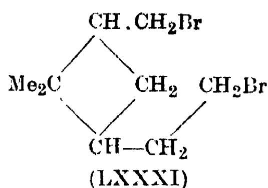
in this laboratory starting from the dibromide (LXXVIII) obtained by Ostling[47] from the corresponding diol (LXXVII), according to the scheme outlined below :



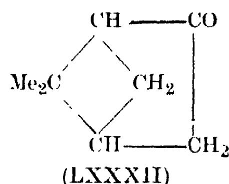
Similarly from pinic ester, Ostling obtained the diol (LXXX) and the dibromide (LXXXI) which with sodium did not give nopinane (II)



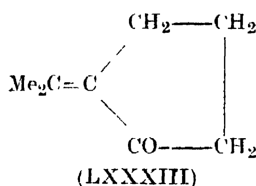
(LXXX)



(LXXXI)



(LXXXII)

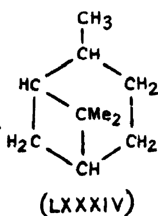


(LXXXIII)

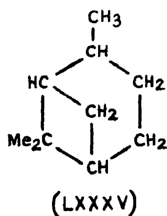
Pinic ester by the action of sodium gives only complex products, and the distillation of lead pinate did not give the expected interesting compound (LXXXII) but only *iso*propylidene *cyclo*pentane-2-one (LXXXIII) obtained also by Bonsdorff[48] by dry distillation of calcium pinate.

Phenomena of Isomerism.

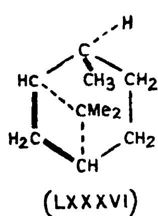
Two isomeric pinanes are known. Nametkin[14] by reducing pinocamphone obtained a compound which he designates as '*pinocamphane*' to distinguish it from *pinane* derived by the reduction of pinones and represents the two as in (LXXXIV)



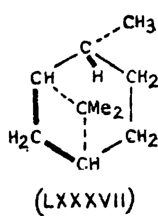
(LXXXIV)



(LXXXV)



(LXXXVI)

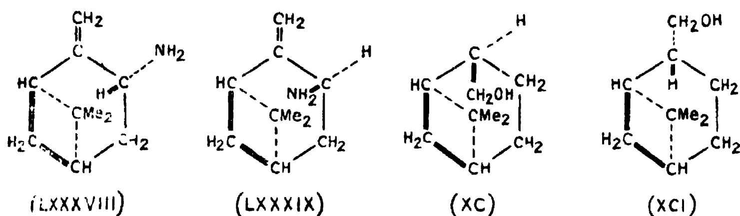


(LXXXVII)

and (LXXXV) which evidently is not correct. Lipp[12] thoroughly investigated the problem and arrived at the conclusion that by the reduction of pinene, two pinanes are produced (*cis* and *trans*) their quantities predominating according to the conditions of reduction ; no work on the configuration of the compounds is, however, recorded. It may be concluded, from the work on the compounds described below, that the *cis* and *trans* isomerism is due to the two possible planar arrangements of pinane as shown in LXXXVI and LXXXVII (atoms connected by dotted lines lying in one plane and those by thick lines in another).

The case of pinane is not a solitary instance in which this peculiar type of isomerism exists. Nitrosopinene is found to be not identical with pinocarvoxime. So, as Ruzicka suggests,[25]

the isomerism is more likely due to difference in the planar arrangements of the atoms, as in pinylamine and pinocarvylamine (LXXXVIII and LXXXIX).



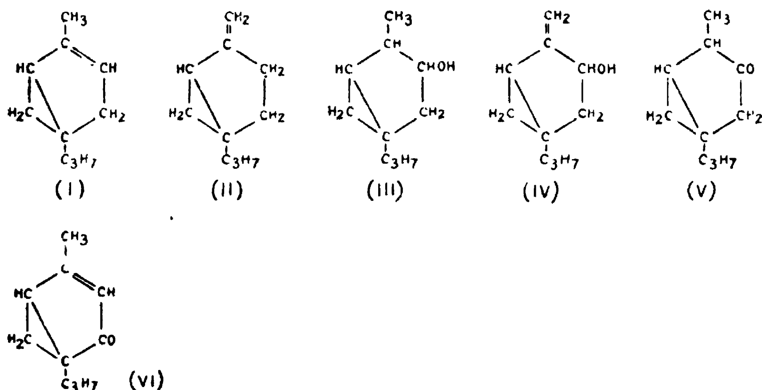
(LXXXVIII) (LXXXIX) (XC) (XCI)

With the present data it is not possible to differentiate between these planar arrangements. The two (*cis* and *trans*) isomeric compounds *iso*myrtanol and myrtanol of Dupont and Zacharewics[20] can therefore be represented as XC and XCI. The existence of two nopinols[22] and two methylnopinols[12 21] are but the requirements of the theory in the light of the work and observations mentioned above. In all the derivatives of pinane, where the ring is completely reduced, such an isomerism should be expected.

A search for such types of isomerism in pinocampheol*, verbanol†, methylverbanol, nopinic acid, etc. is expected to yield fruitful results and determination of configuration of the isomers will give an insight into the stereo-chemistry of these bicyclic systems.

Thujane Series.

Only a few members of this group, e.g. α-thujene (I), *d*, *l*, and *dl*-sabinene (II), thujyl alcohol (III), sabinol (IV),



* 1-2-Pinocamphenols are known (cf. p. 5).

† Verbanol is obtained as a mixture of isomerides[18].

thujone (V) and umbellulone (VI) are known to occur in nature. Yet a rational study of the reactions of the individual members, or systematic attempts towards the synthesis of the parent members and their degradation products, do not appear to have been made, perhaps for the following reasons.

(1) They do not give characteristic crystalline derivatives for identification purposes, nor are they easily purified. Some of the natural hydrocarbons, e.g. α-thujene, slowly recemise on keeping and thujone changes to the isomeric *iso*thujone on heating. Oils containing thujone become strongly acidic when preserved, mainly owing to the formation of α-thujaketonic acid.[1]

(2) Most of the members of this group contain more than one asymmetric carbon atom giving rise to a large number of stereoisomers. This fact is borne out by the works of Kondakov and Skwarzov,[2] Tschugaev, and Fomin[3] in the case of α- and β-thujenes, of Henderson and Robertson[4] and of Paolini, Divizia and Rebora[5] in the case of thujyl alcohol, sabinol and thujone.

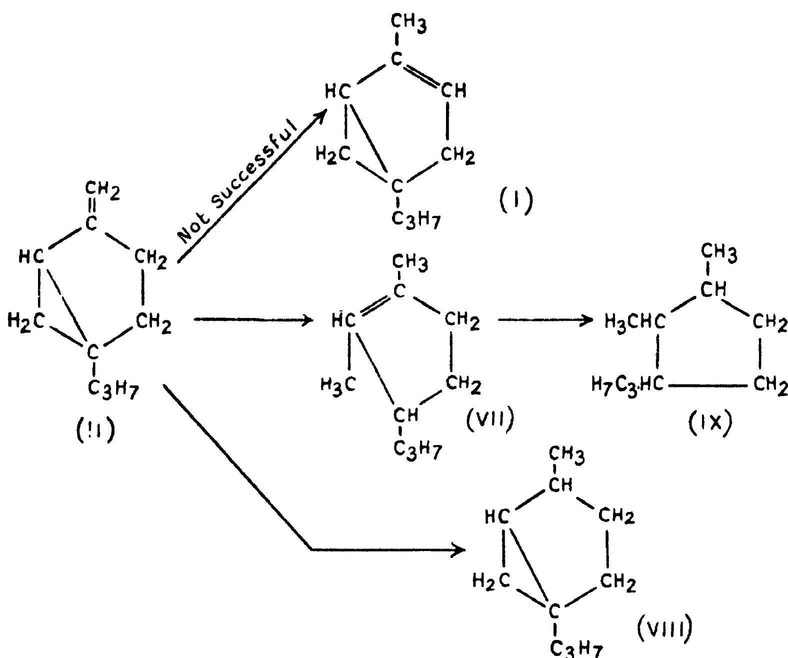
(3) The oxidation products, chiefly dicarboxylic acids, e.g. homothujadicarboxylic acid can exist in *cis-trans*-modifications, besides displaying stereochemical isomerism.

(4) The ease with which the *cyclo*propane ring of this group opens is in marked contrast to the case of carenes, which are quite stable towards dilute sulphuric acid, and the instability of the *cyclo*propane ring is shown generally in almost all their reactions with HCl, HBr, Br, CrO_3, $KMnO_4$, hydrogenation with Pd, etc., and also on dehydrogenation. Either monocyclic six-membered derivatives such as terpene dihalogenides, terpinene-4-ol, 1 : 4-terpin or derivatives of the five-membered *iso*thujone group (X–XIII) such as α-thujamenthol, *iso*thujone oxime, *iso*thujylamine are formed by the fission of the *cyclo*propane ring in two different ways depending upon how the ring opens.

Rearrangement of bicyclic six-membered compounds into iso*thujone or* cyclo*pentane derivatives.*

(*a*) *By catalytic hydrogenation.*—Richter, Wolff, and Presting[6] during their unsuccessful attempt to convert sabinene (II) into the difficultly obtainable α-thujene (I) under the influence of Pd black, analogously with rearrangement of β-pinene to α-pinene, found that sabinene is converted into 1 : 2-dimethyl-3-*iso*propyl-*cyclo*pentene (VII) (the position of the double bond being uncertain), involving thereby a mechanism similar to that observed by Wallach[7] in the rearrangement of thujone to the five-membered ring ketone, *iso*thujone. They found on repeating the work of Tschugaev and Fomin[8] that with

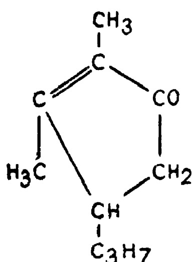
platinum black the hydrogenation of sabinene follows a different course. It stops when about two atoms of hydrogen have been taken up and yields a product stable towards perbenzoic acid and corresponds to thujane (VIII) in its properties. They further show that the hydrocarbon (so-called dihydrosabinene) obtained by Wallach[7] with colloidal Pd, and also by them with Pd black was VII, which further absorbs hydrogen with almost undiminished activity giving 1 : 2-dimethyl-3-*iso*propyl*cyclo*-pentane (IX) whose physical constants, as given by Taboury and Godchot,[8] were shown to be incorrect by Kasansky.[9] They infer that the difference between the reaction with Pd and Pt, is probably due to the special activity of Pd as a dehydrogenation catalyst.



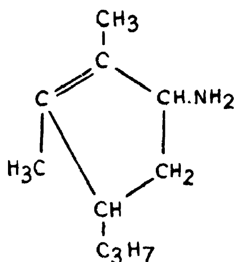
Observations have been made by Zelinsky and Kasansky[10] that α-thujene on distillation over nickel in an atmosphere of hydrogen, thujane by Sabatier and Senderen's process of hydrogenation[11], sabinol on catalytic hydrogenation with nickel, Pd and Pt[4, 12], and thujone in the presence of Pd asbestos[9, 10] give the same 1 : 2-dimethyl-3-*iso*propyl*cyclo*pentane, whose constitution has been definitely established by Kasansky.[9] While under other conditions, viz. reduction under pressure at room temperature in presence of platinum, there is no rupture of the *cyclo*propane ring, the product being thujane.[3] It is noteworthy that thujene with a less stable bicyclic structure behaves similarly to pinene. Using osmium as hydrogenation

catalyst, Zelinski and Pollak [13] found that α-thujene gave thujane without the rupture of the *cyclo*propane ring.

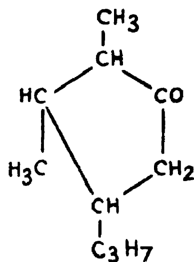
(*b*) *Miscellaneous reactions.*—The rearrangement of the members of the thujane group into those of *iso*thujone is characteristically represented by the conversion of sabinol to *iso*thujone (X) on heating with aluminium *iso*propylate [14], of thujone into *iso*thujone (i) on being heated with sodium [14] and also with ammonium hydrogen sulphide [15]; (ii) on distillation over copper or nickel [16]; (iii) by Sabatier and Senderen's process of reduction [17]; (iv) by concentrated sulphuric acid.[18, 19, 20] Other examples of this rearrangement are the reduction of thujone oxime (liquid) by sodium and alcohol to *iso*thujylamine [21] (XI) and the conversion of thujone to thujamenthone (XII) by reduction in presence of nickel and hydrogen.[17]



(X)



(XI)

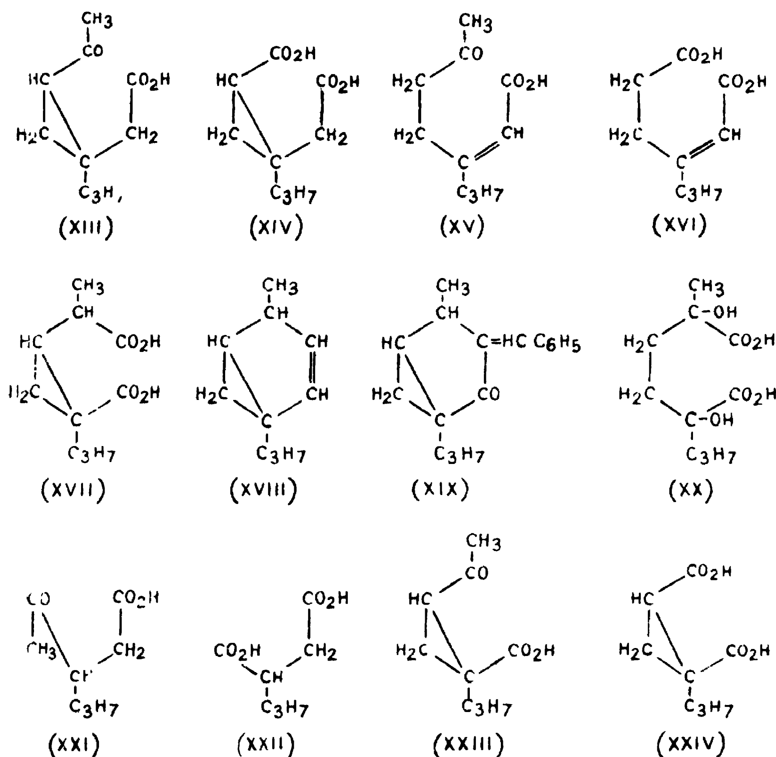


(XII)

Transformation of the bicyclic compounds into *cyclo*hexane derivatives can be seen from the following: α-thujene and sabinene give terpinene dihalogenides with halogen acids and 1 : 4-terpin and terpinene-4-ol with sulphuric acid [22]; sabinaglycerol gives cumin alcohol and sabinol gives Δ'-*p*-menthane-4 : 6-diol and Δ'-*p*-menthane-4 : 6 : 7-triol with warm sulphuric acid [23]; sabinol gives carvotanacetone by distillation over copper and nickel [16]; thujone gives carvacrol by the action of ferric chloride [24, 19] and by sulphur.[25] The last two reactions illustrate the simultaneous ring fission and dehydrogenation of thujone.

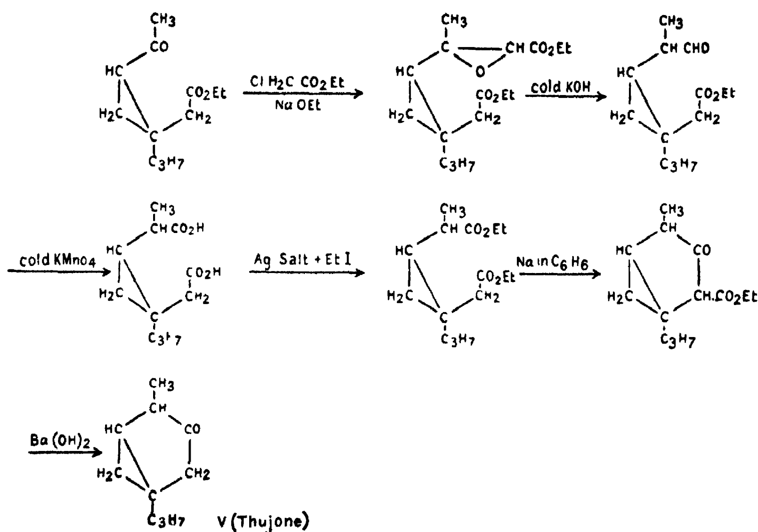
The large number of oxidation reactions so far studied have resulted in the isolation of numerous interesting acids. α-Thujaketonic acid (XIII), α-thujadicarboxylic acid (XIV), β-thujaketonic acid (XV), and β-thujadicarboxylic acid (XVI) arise from oxidation of α-thujene, sabinene, β-thujone by $KMnO_4$ and NaOBr [2, 23, 26 32]; *dl*-homothujadicarboxylic acid (XVII) by the oxidation of β-thujene [21, 23] (XVIII); *d*-homothujadicarboxylic acid by the oxidation of benzylidene β-dihydroumbellulone [34] (XIX); *l*-homothujadicarboxylic acid from benzylidenethujone; α,δ-dihydroxy-α-methyl-δ-*iso*propyladipic acid (XX) by the H_2O_2 oxidation of sabinene [4]; β-*iso*propyllaevulic acid (XXI) and β-*iso*propylsuccinic acid (XXII) by CrO_3 oxida-

tion of *iso*thujone; umbellulonic acid (XXIII) and umbellularic acid (XXIV) from the oxidation of umbellulone.[35, 36] It remains for chemists, keeping in mind the peculiar behaviour and possibilities of ring opening characteristic of members of this series, to make some well-planned attacks on their synthesis.

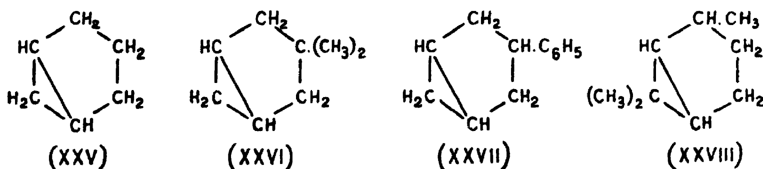


Thujone, obtained from several sources in nature (in thuja, tansy, sage and worm wood oils) although structurally identical does not exhibit the same properties, because all do not yield the same crystalline bisulphite compounds or crystalline oximes. Furthermore, there is observed a marked difference of optical rotation in both sign and value. The tendency to undergo inversion, caused either by acids or alkalis, and the governing conditions have not been closely studied. Elucidation of the structure of this interesting ketone presented considerable difficulties, but after an elaborate investigation by Semmler, Wallach and others, it is now definitely established. The partial synthesis [37] of thujone by Ruzicka and Koolhaas starting from α-thujaketonic acid (cf. conversion of pinonic acid into pinocamphane and α-pinene by Ruzicka and Trebler, affords the firmest support for Semmler's thujone formula (V).

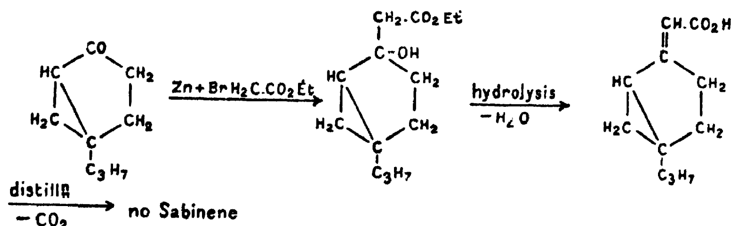
Mention may be made here of the synthesis of bicyclic hydrocarbons possessing the thujane skeleton. The parent



hydrocarbon, northujane (XXV) [*bicyclo*-(0 : 1 : 3)-hexane], has been synthesized by Zelinski and Ushakov.[38] 3 : 3-Dimethyl-*bicyclo*-(0 : 1 : 3)-hexane[39] (XXVI) 3-phenyl*bicyclo*-(0 : 1 : 3)-hexane[40] (XXVII) and 2 : 6 : 6-trimethyl-*bicyclo*-(0 : 1 : 3)-hexane[4] (XXVIII) have been synthesized.



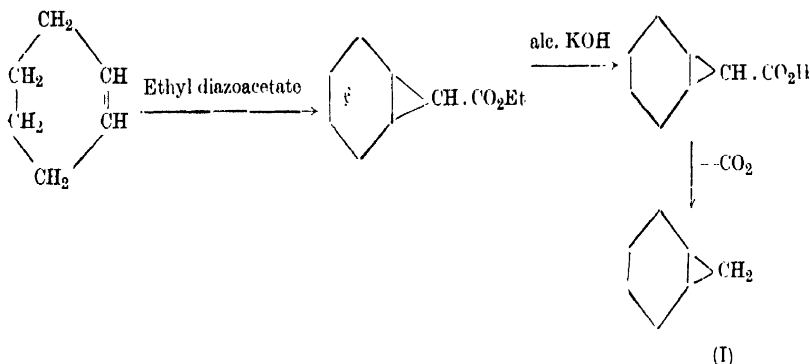
The unsuccessful attempt towards the synthesis of sabinene from sabinaketone also deserves mention.



Attempts have been made to synthesize compounds of the thujane group by bridging ethyl *cyclo*hexanone-2 : 6-dicarboxylate[42] in 2 : 6-positions by Guha and Seshadriengar. Work is also in progress in this laboratory to build up the thujane skeleton from *cyclo*propane 1 : 2-dicarboxylic anhydride (cf. Guha and Ranganathan).[43]

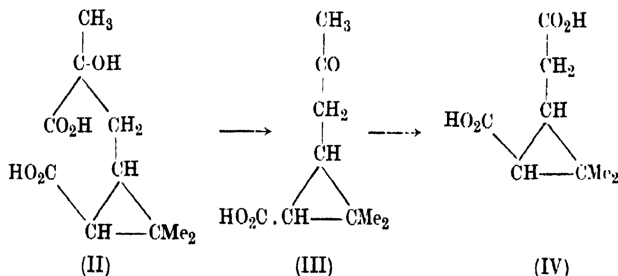
Carane Series.

A great advance towards the synthesis of members of the carane group has recently been made by Ebel, Brunner, and Mangelli[1] by synthesizing norcarane (I) starting from *cyclo*hexene as follows:



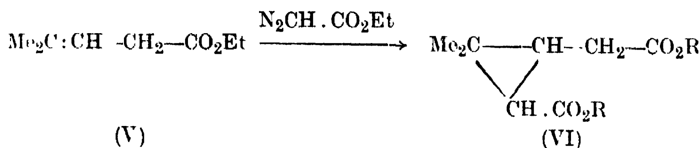
Δ^3-*Carene.*

The constitution of Δ^3-carene has been deduced from a study of the oxidation with potassium permanganate and with ozone. giving amongst other products two laevo-rotatory hydroxy-dibasic acids and *cis*- and *trans*-caronic acids, the last one having been synthesized by Perkin and Thorpe.[2] The hydroxy-acids are probably *cis-trans*-isomerides, the lower melting one being the *cis*-modification, since on being heated with acetyl chloride it yields a lactone, partial conversion into the *trans*-modification occurring simultaneously. Although these two hydroxy-acids (II) are both stable to alkaline permanganate they are oxidized, however, by acid permanganate to isomeric ketonic acids (III).



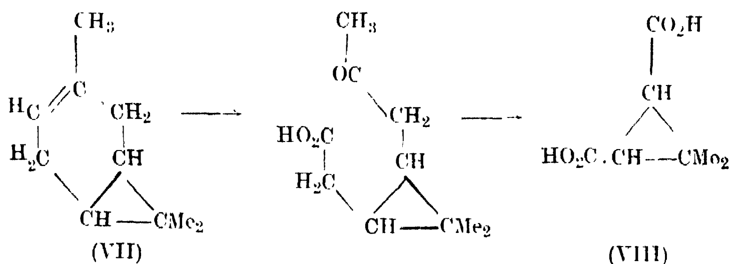
Oxidation of the *cis*-acid (III) with sodium hypobromite gave *cis*-homocaronic acid (IV), synthesized by Owen and Simonsen[3] by condensing ethyl Δ^β-*iso*hexenoate (V) with ethyl diazoacetate in presence of copper bronze when a mixture of the

esters of *cis*- and *trans*-homocaronic acids (VI) and *cyclo*-butane-1 : 2 : 3 : 4-tetracarboxylic acid was obtained.



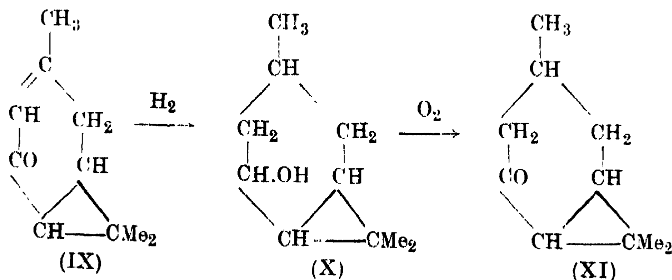
Although direct synthetic evidence of the constitution of Δ^3-carene and of its degradation products is not available with exception of the caronic acids and the homocaronic acids—there would appear to be little doubt that it is correctly represented by formula (VII).

Oxidation of *d*-Δ^3-carene with Beckmann's chromic acid mixture gives *l*-*trans*-caronic acid (VIII) besides *d*-homoterpenylmethylketone, terpenylic acid and terebic acid.[4]



The formation of *l*-*trans*-caronic acid in the above oxidation is of interest, since the ketonic acid, from which it must originate, would probably have the *cis*-configuration. Under the experimental conditions, this configuration must be presumed to be unstable, passing into the *trans*-form, which is then further oxidized to the *trans*-dibasic acid.

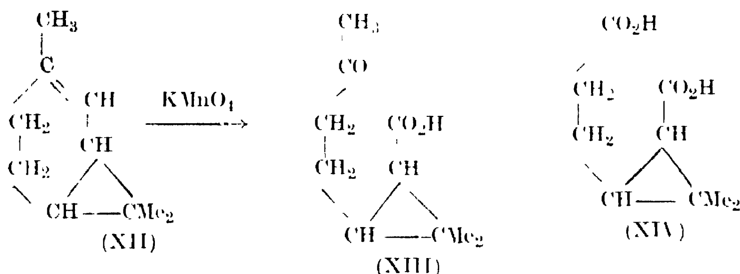
Mention has already been made of the principal products which are formed when *d*-Δ^3-carene is oxidized with potassium permanganate in acetone solution. Semmler and Schiller separated an unsaturated dicyclic ketone[5] (IX) from the neutral oxidation products, which on reduction with sodium and alcohol gives the saturated alcohol (X) yielding on oxidation with chromic acid, the saturated ketone (XI).



No direct proof of the constitution of any of the above substances is available and the formation of an unsaturated ketone by oxidation with potassium permanganate appears to be somewhat unusual.

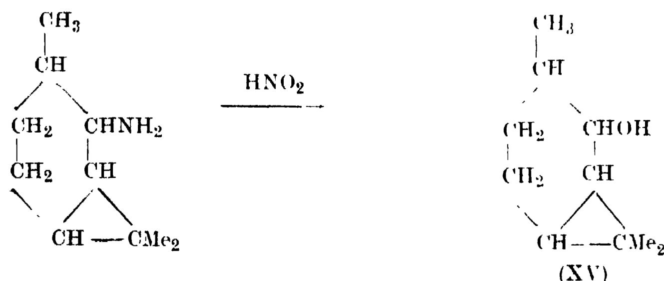
Δ^4-*Carene.*

Δ^4-Carene (XII) is oxidised with $KMnO_4$ in acetone solution to *d*-1 : 1-dimethyl-2-γ-ketobutyl*cyclo*propane-3-carboxylic acid (XIII) recently synthesized by Owen and Simonsen[6] by the condensation of methylheptenone with ethyl diazoacetate and subsequent hydrolysis of the ester group. The acid (XIII) is oxidized with sodium hypobromite to *d* 3-carboxy-1 : 1-dimethyl-*cyclo*propane-2-propionic acid (XIV), the constitution of which has been proved by its conversion into homoterpenylic acid.



The methylxanthate of 1-carol obtained from *d*-carylamine gave on distillation a hydrocarbon whose constants agree closely with those of Δ^4-carene.[7] Ruzicka[8] in his recent attempt to synthesize Δ^4-carene from caryltrimethylammonium iodide, under varying conditions of experiment, obtained two *monocyclic* hydrocarbons, $C_{10}H_{16}$ one of which is reduced to a hydrocarbon $C_{10}H_{20}$.

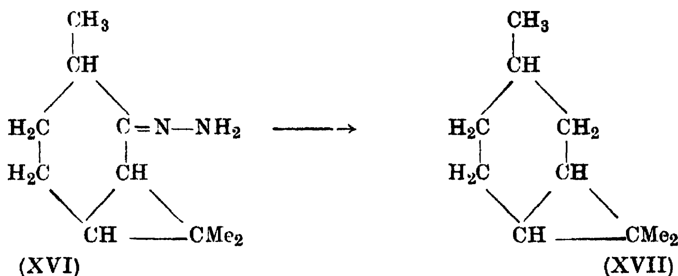
Reduction of carone to the corresponding secondary alcohol, carol (XV) cannot be effected, although this alcohol has been prepared by Menon and Simonsen[9] by treating *d*-carylamine with nitrous acid.



d-Caronehydrazone (XVI) is an oil which, when distilled with potassium hydroxide, gives the saturated dicyclic hydro-

carbon, *l*-carane (XVII).[10] This conversion of caronehydrazone into *l*-carane also occurs when it is heated with sodium ethylate under pressure.[11]

These methods of converting the ketone into a hydrocarbon are likely to be of considerable use in synthetic work.



Attempts have been made by Guha and Ghosh[12] to synthesize compounds of the carane series starting from succinyldimalonic ester *via* ethyl *cyclo*hexane-3 : 6-dione-1 : 1 : 2 : 2-tetracarboxylate and the corresponding diacid ester containing two active hydrogen atoms in 1 : 2-positions. Work is also in progress to build up the carane skeleton from tetramethylene dimalonic ester, through the *cyclo*heptanone-2 : 7-diester.

I shall conclude by expressing my thanks to you for giving me a patient hearing and to my students K. Ganapathi, T. N. Ghosh, B. H. Iyer, S. K. Ranganathan, and N. K. Seshadriengar for their help in compiling some of the references in connection with this address.

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Section of Chemistry.

Abstracts.

INORGANIC CHEMISTRY.

1. Resolution of co-ordinated inorganic compounds. Part III: Active cadmium propylenediamine salts.

PANCHANAN NEOGI *and* K. L. MONDAL, Calcutta.

The work commenced by Neogi and G. K. Mukherji had to be repeated owing to the lamented early death of Mr. Mukherji. Co-ordinated cadmium salts with both *d*- and *l*-trispropylenediamine have been isolated.

2. Salts of gallium : Part I.

PANCHANAN NEOGI *and* S. K. NANDI, Calcutta.

Several new salts of gallium have been prepared.

3. Complex compounds of biguanide with tervalent metals: chromium and cobalt.

P. R. RÂY *and* HARIBOLA SAHA, Calcutta.

Though the complex biguanide compounds of bivalent copper, nickel, and cobalt have been described long ago, the constitution of the complex metal-biguanide ion is still under dispute. In order to elucidate this unsettled problem the authors have prepared and studied the properties of biguanide complexes of tervalent chromium and cobalt. These compounds, which have not yet been described in the literature, form beautiful ruby-red crystals—the colour being more prominent in the case of chromium complex. They are strong bases. Three molecules of biguanide are co-ordinated with each metallic atom—the biguanide acting as a bidentate group. The co-ordination number of the metal atom in these complexes, as well as their physical and chemical properties, throw a flood of light on their constitution and those of biguanide complexes in general.

4. Complex metal-ammonium selenites and selenito-metal-ammines.

P. R. RÂY *and* A. B. GHOSH, Calcutta.

A number of complex metal-ammonium selenites and selenito-metalammines have been prepared. All the latter contain cobalt as the central atom, and the selenito group occupies in them only one co-ordination position like the corresponding sulphito group. Unlike the sulphito complexes, however, these are readily hydrolyzed giving rise to aquo-compounds. Co-ordinating capacity of the selenito group is, therefore, very weak, possibly due to its larger volume.

Among the metal-ammonium selenites, compounds with cobalt, nickel, and copper as the central atoms have been prepared.

5. The action of hydrogen sulphide on barium and mercurous chromates.

M. A. HAMID*, V. S. BHATIA, *and* H. B. DUNNICLIFF, Lahore.

Purified hydrogen sulphide was bubbled through suspensions of the chromates in water. Barium chromate gives a precipitate containing the hydroxide, thiosulphate (co-ordinated), sulphate (co-ordinated), barium sulphate (traces), and sulphur. The filtrate contains barium thiosulphate and polysulphide. Tetrathionate was not detected as an intermediate or bye product. At 80–85° the sulphate increases and thiosulphate decreases.

At low temperatures, sulphite is detected among the products of reduction of mercurous chromate, but none is found when the gas is passed at 80–85°C.

6. The slow oxidation of hydrogen sulphide in aqueous solution.

H. B. DUNNICLIFF, Lahore.

Hydrogen sulphide is decomposed freely, giving water and sulphur. Sulphur reacts with water forming sulphoxylic acid (H_2SO_2) and hydrogen sulphide. The sulphoxylic acid is oxidized to sulphurous acid which may combine with either oxygen or sulphur giving sulphate or thiosulphate. In some cases, both of these reactions proceed simultaneously but the fate of the sulphurous acid depends upon the nature of the bases present, sulphide being completely suppressed in alkaline media, giving thiosulphate, and in feebly or strongly acid media containing a moderate concentration of oxidizing agents, giving sulphate.

Side reactions show that, in certain circumstances, dithionate can be formed from sulphite and tetrathionate by the mild oxidation of thiosulphate.

It is most improbable that thiosulphate is formed by the condensation (with loss of one molecule of water) of two molecules of sulphoxylic acid or that sulphate is the result of the hydrolysis of the thiosulphates of weak bases.

7. Electro-deposition of chromium from potassium dichromate baths. Part I: In presence of sulphate.

S. R. PATHAK *and* S. HUSAIN, Hyderabad (Deccan).

Bright white deposits of chromium were obtained from potassium dichromate baths, containing sulphuric acid or potassium hydrogen sulphate. Baths containing potassium sulphate yielded grey deposits. The current efficiency in the case of sulphuric acid was about 9% and in the case of potassium hydrogen sulphate about 5%. It was very low in the case of potassium sulphate.

8. Electro-deposition of chromium from potassium dichromate baths. Part II: In presence of acetate.

S. R. PATHAK *and* S. HUSAIN, Hyderabad (Deccan).

Shining white deposits of chromium were obtained from potassium dichromate baths containing acetic acid or sodium acetate. The current efficiency in the case of acetic acid baths was about 14% and in the case of sodium acetate it was about 0·6% only.

9. Study on the alkaline Nessler's reagent.

P. B. SARKAR *and* B. C. RAY, Calcutta.

Neutral Nessler's reagent does not give characteristic precipitate with free ammonia. The presence of caustic alkali is indispensable. In ordinary text-books the roll of OH′ ion is not properly taken consideration of. Physico-chemical methods have been applied to study the behaviour of HgI_4'' ion in presence of OH′ ion.

10. The metallic constituents of certain Indian foods and vegetables: complete quantitative analysis (chemical and spectrographical).

P. B. SARKAR *and* H. C. GOSWAMI, Calcutta.

The present paper forms the first communication of a systematic examination of all the metallic constituents present in Indian vegetables. The following species have been analyzed :

Atap rice ; Musa sapientum ; Momordica charantia (bitter variety); Trichosanthes dioica, ; Piper betle. All of them contain the following metals per kg. :—

Cu, 0,5 to 2,5 mg. ; Mo, 0·03 mg. ; Fe, 1,4 to 31,17 mg. ; Al, 21,6 mg. ; Zn, 1,2 to 2,4 mg. : Mn, 0·12 to 3.5 mg. ; CaO, 245 to 984 mg. ; MgO, 250 to 569 mg. : Na_2O, 377 mg. : K_2O, 4900 mg.

11. Inorganic constituents of Indian vegetables.

K. KONDAIAH, Benares.

A systematic analysis of a large variety of Indian vegetables, for their inorganic constituents, has been undertaken. The materials are first dried and then ashed in platinum. The ash is then analyzed according to standard methods. The constituents estimated include iron, manganese, phosphorus, alkalis, and silica. Manganese, iron and phosphorus have so far been estimated in the following vegetables : sova sag, palak sag, bathua sag, bendi, bohada, som, bigan, paravar, nenua, lauki, kohada. When the data of the analyses are complete, an effort will be made to study the influence of these inorganic constituents on nutrition.

12. On the formation of complexes between manganic fluoride and potassium fluoride.

R. C. RAY *and* H. C. MITRA, Patna.

The formation of complexes between manganic and potassium fluorides has been investigated. It has been found that only two complexes of the formulæ MnF_3,KF and MnF_3,2KF are formed.

13. A method of qualitative analysis without the use of hydrogen sulphide.

M. R. RANE *and* K. KONDAIAH, Benares.

This scheme of qualitative analysis of the common basic radicals, which dispenses with the use of hydrogen sulphide, is simple, expeditious and accurate. The bases are separated into five main groups. The first group (A) consists of silver chloride and the insoluble oxides of antimony and tin, formed by hydrochloric and nitric acids. The second group (B)

includes barium, strontium, and lead, which are precipitated as sulphates by ammonium sulphate in acid medium. The third group (C) consists of iron, aluminium, chromium, manganese, bismuth, calcium, and magnesium, which do not form soluble ammoniacal complexes with ammonia and are precipitated by ammonia and ammonium phosphate. Cobalt, nickel, copper, cadmium, and mercury, which are precipitated as oxides or hydrated oxides, when their ammoniacal complexes are boiled with sodium hydroxide are included in the fourth group (D) while zinc and arsenic remaining in solution to the end constitute the fifth group (E). Alkalis and ammonium are tested for separately in the original mixture.

PHYSICAL CHEMISTRY.

14. On the photo-bromination of acetylene dichloride in the gaseous phase and in carbon tetrachloride solution.

J. C. GHOSH, S. K. BHATTACHARYYA, *and* S. C. BHATTACHARYYA, Dacca.

The photo-bromination of acetylene dichloride in the carbon tetrachloride solution has been done in three different frequencies, 406, 436, and 546 $\mu\mu$. The reaction is unimolecular with respect to bromine. The reaction was carried out at 30°C. At this temperature there is no dark reaction between the components of the reaction mixture. This reaction has got the following characteristics :—

(*a*) The unimolecular velocity constant with respect to bromine diminishes slightly with time.

(*b*) The velocity constant diminishes with diminishing concentration of the acetylene dichloride when the concentration of the latter is below ·0054M, according to the relation 1/K plotted against 1/C gives a straight line. When the concentration of the acceptor exceeds ·0054M, the velocity constant is practically independent of the concentration of the acceptor.

(*c*) Temperature coefficient is 1·4 for 546 $\mu\mu$; 1·38 for 436 $\mu\mu$; and 1·35 for 406 $\mu\mu$.

(*d*) γ is equal to 2 for 546 $\mu\mu$: 6 for 436 $\mu\mu$; and 9 for 406 $\mu\mu$.

A mechanism has been suggested to explain the above facts.

The photo-bromination of acetylene dichloride in the gaseous phase has been done in 436 $\mu\mu$ at 30°C. There is no dark reaction at this temperature. The mechanism of the gaseous reaction has been found to be identical with that of the reaction in CCl_4 solution. Only the quantum efficiency γ has been found to be a little higher in the gaseous phase.

15. Effect of the simultaneous action of radiations of different frequencies on the photochemical oxidation of mandelic acid by bromine.

J. C. GHOSH *and* S. K. BHATTACHARYYA, Dacca.

The kinetics of the reaction were first separately studied in three monochromatic radiations 366, 436, and 546 $\mu\mu$ and then, under the simultaneous action of the ultraviolet (366 $\mu\mu$) and the blue (436 $\mu\mu$); the ultraviolet (366 $\mu\mu$) and the green (546 $\mu\mu$) and the blue (436 $\mu\mu$) and the green (546 $\mu\mu$) radiations. The reaction is zeromolecular with respect to bromine in presence of potassium bromide. The bromination was carried out at 31·5°C. At this temperature there is a slight unimolecular dark reaction between the components of the reaction mixture. The reactions were studied in two different concentrations of bromine and bromide, the composition of the reaction mixture being those used by Ghosh and Purkayastha (Z. Physik. Chem. Abt. B. Bd 7, Heft 4, 285, 1929).

The results obtained are peculiar in the following respects :—

(*a*) The combined effect of two radiations is always less than the sum of the two individual effects.

(*b*) The velocity constant in pure monochromatic radiation varies as the square root of the intensity of the absorbed radiation.

(*c*) γ for 366 $\mu\mu$ varies from 25 to 100; for 436 $\mu\mu$ varies from 13 to 57; and for 546 $\mu\mu$ varies from 3 to 12.

A mechanism has been given to account for the above observed peculiarities.

16. Effect of ultraviolet light on ferric salts of organic acids.

P. B. GANGULI *and* PANNALAL, Patna.

Ferric salts of citric, tartaric, salicylic, and malonic acids were prepared from freshly precipitated ferric hydroxide and exposed to ultraviolet light. The rate of reduction was followed by Mohr's iodometric method (*Ann. d. Chem. U. Pharm.*, 105, 53). The order of the reactions has been found to be mono-molecular. In a quartz vessel the reaction is much more rapid than in a glass vessel (cf. *Benrath. Zeit. phys. Chem.*, 74, 150, 1910). This is not a surface effect, as addition of silica gel has a slight retarding influence. Light of wavelength greater than 4850Å units is inoperative. The effects of traces of copper, uranium, and thorium have been investigated.

Freshly precipitated ferric hydroxide dissolves in stoichiometric quantities of the organic acids to form in the beginning a colloidal solution, which gradually passes over to a crystalloidal form. This has been followed by dialysis and estimation of the dialysate.

17. Raman spectra of *cis* and *trans* decalins.

S. K. KULKARNI JATKAR, Bangalore.

In continuation of previous work the shifts 539 (0), 595 (3), 794 (1), 1040 (2), 1270 (5), 1347 (3b) have been found to be characteristic of *cis* and 495 (5), 881 (3), 957 (1), 996 (2), 1145 (3), 1234 (1), 1363 (5b) are characteristic of *trans* decalin. A comparison of these observations with the Raman spectra of *cis* and *trans ortho* dimethyl cyclohexane shows that the *cis* and *trans* positions in these compounds are similarly configurated to that of *cis* and *trans* decalin, and brings out the persistence of group frequencies in increasingly complex compounds.

18. Raman spectra of α- and β-picolines, quinoline, quinaldine, and *iso*quinoline.

S. K. KULKARNI JATKAR, Bangalore.

Evidence has been found in the Raman spectra in support of the peculiar and characteristic properties of these compounds, such as the dual nature of the stability of the constituent rings when compared with naphthalene and the reactivity of the methyl group.

The occurrence of paired lines at 500, 1000, 1278, 1430, and 1550 Cm^{-1} in *iso*quinoline indicate the existence of two forms of this compound, one having a quinoline structure and the other quinaldine structure.

19. Raman spectra of terpenes and camphors.

S. K. KULKARNI JATKAR *and* R. PADMANABHAN, Bangalore.

The marked differences in the Raman spectra of limonene and dipentene have been shown to be due to the different amounts of the products of intramolecular isomerization, namely, terpinolene and α

terpinene present in these compounds, the latter predominating in the technical dipentene.

There are three faint shifts 1412 (1), 1440 (1) and 1480 (0) Cm^{-1} in camphor, and only two lines 1450 (5) and 1484 (2) in fenchone, the smaller value and lower intensity of the band in camphor being due to the reactive nature of the methylene group.

20. On the formation of liesegang rings in the presence of precipitates. Part I: Action of potassium ferrocyanide on ferric chloride in presence of calcium sulphate and barium sulphate precipitates.

B. N. SEN, Calcutta.

Known volumes of the solution of potassium ferrocyanide were kept over thickly set bodies of the precipitates of calcium sulphate and barium sulphate prepared by moistening given weights of these precipitates with ferric chloride solution. It was found that the prussian blue precipitates appeared in the form of periodic rings in the uniformly set bodies of these precipitates. The number, the thickness of and the distance between the rings have been studied with reference to the concentration of the reactants, acidity of the medium and to other factors which generally influence the characteristics of the rings.

21. On the formation of liesegang rings in presence of precipitates. Part II: Action of potassium ferrocyanide on copper sulphate in presence of calcium sulphate and barium sulphate precipitates.

B. N. SEN, Calcutta.

Uniformly set bodies of the precipitates of calcium sulphate and barium sulphate were prepared by moistening given weights of these precipitates with copper sulphate solution. Known volumes of potassium ferrocyanide solution were kept over these bodies, when it was found that the copper ferrocyanide precipitate appeared in the form of periodic bands in the uniformly set bodies of these precipitates. The characteristics of the bands have been studied with reference to the concentration of the reactants and the acidity of the medium.

22. Effect of lyophillic colloids on the wettability of naphthalene by water.

A. C. CHATTERJI, Lucknow.

It has been pointed out by J. Traube (*Chemikar Ztg.*, 1924, **48**, 633, 673) that the addition of minute quantities of lyophillic colloids considerably influences the wettability of ores when a separation of these is attempted by the flotation process. In a number of former papers (*Kolloid Beiheften*, 10/12 Band 38, 1933; *Proc. Ind. Sc. Cong.*, 1934) it has been pointed out that there exists a close relation between capillary activity and wettability, and further the wettability of pure chemicals like naphthalene, anthracene, and phenanthrene, are also considerably affected by capillary active substance.

In this paper the effect of adding minute quantities of some lyophillic colloids on the wettability of naphthalene has been studied. The colloids examined are gelatin, casein, starch, agar-agar, and silicic acid.

The method employed for the determination of wettability is the one described in Kolloid-Beihefte. According to the results obtained the colloids can be arranged in the following order :—

gelatin > casein > starch : agar-agar > silicic acid.

It is interesting to compare this series with that obtained on a basis of their gold numbers,—

gelatin > casein > starch > silicic acid.

23. The anomalous coagulative power of mercury chloride.

S. S. Joshi *and* K. R. Das, Benares.

In a communication to be published shortly in *J. Indian Chem. Soc.*, results are presented to show that during the slow coagulation of colloid arsenious sulphide by aqueous solutions of mercury chloride, the variation of the viscosity, the transparency and the refractive index are abnormal. Systematic determinations were, therefore, made of the coagulative power (relative) of the above substance in the case of a number of colloids. This quantity was found to be abnormally high, and has been discussed especially in view of the fact that aqueous solutions of mercury chloride show but negligible ionization, as judged by conductivity and other allied data.

24. Influence of high temperature ageing on the refractivity of colloids.

S. S. Joshi *and* P. V. Jagannath Rao, Benares.

This was undertaken in order to investigate the general nature of factors which determine the refractive index of a colloidal solution.

To this end, variously concentrated colloidal solutions of manganese dioxide, antimony sulphide, arsenious sulphide, cupric oxide, sulphur, vanadic acid, aluminium hydroxide, selenium, silver, cadmium sulphide, prussian blue, copper ferrocyanide, mercuric sulphide, gold, ferric hydroxide, and some oil emulsions were held at 100°C. about 3·5 hours, under reflux condenser and at constant colloid content. In all these systems, except with aluminium hydroxide, the refractivity was found to increase by subjecting the sol to heat as mentioned above, and the change in the refractive index was independent of the nature of the colloid.

25. Coagulation of colloid manganese dioxide in the slow region.

S. S. Joshi *and* P. V. Jagannath Rao, Benares.

Kinetics of the slow coagulation of colloid manganese dioxide has been studied in the presence of various amounts of potassium, barium, mercury and aluminium chlorides, and lanthanum and thorium nitrate. The course of coagulation was followed by measurement of the viscosity and the refractive index of the coagulating sol. In agreement with previous results with a number of other sols whose coagulation kinetics have been studied in these laboratories (Joshi and collaborators, *J. Indian Chem. Soc.*, 1933, *10*, 329; 1933, *10*, 599; 1934, *11*, 133; 1934, *11*, 555–571; 572–577; 1934, *11*, 797–804; *J. Chem. Phys.*, 1935, *32*, 455) it was found that coagulation in the slow regions showed usually an initial viscosity diminution and a discontinuous variation. The use of the refractive index to follow the course of coagulations, developed first in these laboratories, has provided curves of striking simplicity, the discontinuities being spaced unambiguously and well distributed in the coagulation time.

26. The effect of light on some colloids.

P. N. Rao *and* M. Qureshi, Hyderabad.

A number of sols were exposed to ultraviolet light. In the majority of cases the P_H values of the systems before and after illumination were

determined. In the case of the ferric hydroxide sol, the P_H values as well as the extinction coefficients of the system before and after illumination for different periods of time were determined. In the case of arsenious sulphide, mercuric sulphide, mastic and gamboge sols the P_H value decreases on exposure to light. With ferric hydroxide sol the P_H values and extinction coefficients both show a decrease on shorter exposures. But prolonged exposures lead to an increase in both the P_H values as well as the extinction coefficients. An explanation for the changes observed in the P_H values and the extinction coefficients of the ferric hydroxide sol has been offered. The effect of ageing on the P_H value of the ferric hydroxide sol is in the same direction as that of the ultraviolet light.

27. Specific heat of colloidal solutions.

S. S. JOSHI *and* G. R. PHANSALKAR, Benares.

A review of the rapidly growing and already very considerable literature on the physical properties of colloids shows the absence of any quantitative data on the heat capacity of these systems. This information is, however, of fundamental importance in the elucidation of the well-known effects of temperature on the different aspects of colloidal behaviour; and as such it is of more than theoretical significance, e.g., in the case of soil colloids. A beginning has, therefore, been made in this line in these laboratories in the determinations of the specific heats of colloidal solutions of arsenious sulphide, antimony sulphide, manganese dioxide, gamboge, and gum-dammer by using an adiabetic calorimeter with an accuracy of at least 12 in 10,000. The specific heat of arsenious sulphide, manganese dioxide, and gum-dammer is found to be less, and that of gamboge to be greater than that of water. The specific heat of antimony sulphide when fresh is greater than that of water; it decreases with ageing and finally falls to a value less than that of water. A similar effect on the specific heat of arsenious sulphide is also found.

28. Studies on desorptions of vapours in silica gel.

R. C. RAY *and* P. B. GANGULY, Patna.

In continuation of the previous work on the adsorption of water vapour by silica gel (*Trans. Faraday. Soc.*, 1934), the desorption of vapours of water, alcohol, and benzene has been determined. The phenomenon of hysteresis has been discussed in the light of the formation of loose adsorption compounds.

29. The velocity of sound in air and steam in narrow tubes.

S. K. KULKARNI JATKAR, Bangalore.

The velocity of sound in air has been determined in smooth brass tubes of 9·5 mm. and 5·5 mm. diameter at frequencies 23586, 49460, 94500 and 127000 cycles and at 25°, 97·1° and 134°. The effect of these factors on the Helmhotz Kirchoff constant is to increase the values at higher temperatures. The corrected values for velocity of air in meters per sec. are 345·7 at 24°, 387·4 at 97·1°, and 399·2 at 134°. For steam the uncorrected values are 493·3 at 94 k.c. and 494·3 at 127 k.c. in a tube of 5·5 mm. diameter.

30. The velocity of sound in organic vapours.

S. K. KULKARNI JATKAR, Bangalore.

Continuing previous work (*Proc. Ind. Science Congress*, Bombay, 1934), the following values of the velocity of sound have been obtained

at 134°, at 94 and 127 k.c. in a brass tube 5·5 mm. in diameter. The values for two frequencies are :

Temperature 134°.

		94 k.c.	127 k.c.
CH_3OH	..	352·9	352·8
EtOH	..	284·3	284·4
n-PrOH	..	250·7	..
Tert-BuOH	..	226·3	..
$(CH_3)_2CO$	..	251·1	251·2
Et_2O	..	217·4	217·5
Ethyl acetate	..	195·3	..
CH_2Cl_2	..	210·6	..
$CHCl_3$	..	179·5	178·1
CCl_4	..	153·6	153·3
$C_2H_4Cl_2$	..	190·1	190·6
C_6H_6	..	212·7	212·8
C_6H_{12}	..	202·1	201·7
nC_6H_{14}	..	199·5	207·3 ?

31. The free energy of organic compounds.

S. K. KULKARNI JATKAR, Bangalore.

Using the values of equilibrium constants obtained by the author and co-workers, the free energy of formation of methyl ether, ethyl ether, *n*-propyl ether, methyl acetate, ethyl acetate, and propyl acetate have been calculated, and the need for further work in this line is emphasized in this paper.

32. The corona pressure phenomenon in gases under electrical discharges due to fields of low frequency.

S. S. JOSHI *and* A. J. HARI RAO, Benares.

It was observed that when elementary gases like nitrogen, hydrogen, and oxygen were subjected to ionization by collision in the annular space of Siemen's tubes, an instantaneous pressure rise of about 2 cm. Hg, followed by a slower pressure change was observed. The influence of initial pressure, applied voltage, the ionization current, frequency of the applied field, capacity (electrical) of the annular space, the type of the discharge, on the magnitude of the initial or the corona pressure change has been investigated. Detailed results are obtained for the actual temperatures of the gas under varying conditions of the discharge. These data, and the fact that the initial pressure rise is independent of the rate of electrode cooling, militate against the adoption of an entirely thermal origin for the initial pressure change. The influence of ozone on the corona pressure rise has been found in general to depress it.

33. The decomposition of nitric oxide in electric discharge due to alternating fields of low frequency.

S. S. JOSHI *and* K. S. VISVANATH, Benares.

The discharge tube was essentially similar to the familiar Siemen's ozoniser, in the annular space of which the gas was exposed to ionization by collision. The potential applied was increased up to about 5,000 volts (r.m.s.). The gas pressure was varied in the range 2·0 to 31·5 cm. Hg. At constant applied voltage, duration of the reaction increased markedly with the gas pressure in a manner not unlike that observed in the case of zero-molecular reactions. Determinations of the ionization

current at different times during the decomposition, and of the gas pressure at constant volume, reveal a striking similarity between the current-time and the pressure-time curves. An intermediate formation of nitrogen peroxide is definitely established. The final products are nitrogen and oxygen in the ratio 1 : 1. The current flowing through the reaction vessel is very markedly affected by the production of nitrogen peroxide. Results are given for the analysis of the decomposition mixtures at different stages of the reaction and also for mixtures analyzed after constant intervals of exposure to discharge at different initial pressures. It has been found that increase of the gas pressure diminishes the velocity of the reaction at constant applied potential. This finding has been discussed from the standpoint of the law of Mass Action and other theories of the phenomenon (Elliot, Josh and Lunt, *Trans. Faraday Soc.*, 1927, *23*, 57).

34. Esterification equilibria in vapour phase.

S. K. KULKARNI JATKAR *and* N. G. GAJENDRAGAD, Bangalore.

Continuing the previous work with silica gel as the catalyst, the following final values have been obtained for the percentage conversion of the equimolecular mixtures of both ethyl and methyl alcohols with acetic acid, viz. 78·5% and 75% at 230° and 250° respectively. The high temperature coefficient is in harmony with the results of Clark and Essex in the range 150°–200°, the importance of our results lying in the fact that the corrections for the association of acetic acid and compressibilities are negligible in the range of temperatures we have tried. The results of all workers have been correlated in this paper.

35. The system methylether-sulphuric acid and *n*-propylether-sulphuric acid.

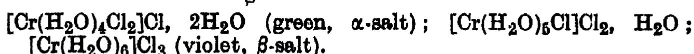
S. K. KULKARNI JATKAR *and* N. G. GAJENDRAGAD, Bangalore.

Although the system sulphuric acid ethyl ether has been studied by Pound (1921) and recently by Usanovich (1934), the study of the systems of sulphuric acid with other ethers has not been reported so far. The authors have recorded the values of conductivity and viscosity of the system sulphuric acid-methyl ether and sulphuric acid-propyl ether. With increasing addition of methyl ether the viscosity drops sharply and remains constant, and again increases rapidly when the molar composition of 50 per cent. is reached. In the case of *n*-propyl ether after the initial drop the viscosity attains a maximum which is one and half times that of pure sulphuric acid, at 50 per cent. molar composition. The maximum conductivity when corrected for viscosity shows a maximum at 94 per cent. of sulphuric acid in both methyl and propyl ethers. The results are compared with the corresponding properties of the system $H_2SO_4-H_2O$ and $H_2SO_4-Et_2O$.

36. Colour transformation in aqueous solutions of chromium chloride.

S. S. JOSHI *and* K. P. N. PANNIKAR, Benares.

It is considered (Meunier and Les Bre, *Comt. rend.*, 1930, *190*, 183–185; Partington and Tweedy, *Nature*, 1926, *117*, 415) that chromium chloride exists in the following isomeric forms :—



$[Cr(H_2O)_4Cl_2]Cl, 2H_2O$ (green, α-salt); $[Cr(H_2O)_5Cl]Cl_2, H_2O$; $[Cr(H_2O)_6]Cl_3$ (violet, β-salt).

An exhaustive study of the conditions, and the kinetics of these isomeric transformations has been made by measurements of (*a*) electrical conductivity, (*b*) absorption spectra, (*c*) refractive index, and (*d*) viscosity.

Results are also given for the influence of exposure to short wave radiations and of temperature in the catalysis of the above changes.

37. A study of the nature of the copper-ammonia complex solutions.

S. S. Joshi *and* K. Vyasulu, Benares.

A study has been made of the nature and constitution of copper-ammonia complexes existing in aqueous solution and similarly coloured solutions obtained by peptizing cupric hydroxide with excess of alkali and organic hydroxy compounds like glycerol, glucose, sucrose, Rochelle salt, etc. Copper ammonia complex solution has been prepared by dissolution of metallic copper in ammonia by the air bubbling process, and by adding ammonia to copper salts. The absorption spectra of these solutions are found to be similar, but colorimetric observations disclosed interesting differences. The depth of light absorption was found to be greater with copper-ammonia solutions than with other systems. Cataphoreses and dialysis experiments indicated the presence of colloidal cupric hydroxide in every case.

The influence on the viscosity of the addition of varying amounts of ammonia to copper salts, cupric sulphate, cupric chloride, and cupric nitrate was also investigated. There was an initial fall in viscosity on the addition of four moles of ammonia to one mole of copper salt. Further addition of ammonia increased the viscosity almost linearly. Thus the viscosity-concentration curves indicated only one definite break corresponding to the addition of four moles of ammonia. The results are in agreement with those obtained by Blanchard in his investigations on the viscosity of the cuprammonium solutions. Results are also obtained for the variation of other physical properties, such as refractivity, in relation to the composition of the mixtures which is most favourable for the complex formation.

38. The electronic theory and the stability of sextets.

P. B. Sarkar *and* B. C. Ray, Calcutta.

Its generalization in explaining the structure of simple ions, inorganic and organic—e.g. carbonate, nitrite, formate, etc. Detailed discussion specially regarding the structure of formate ion from chemical and physico-chemical data.

39. The kinetics of the benzoin reaction in the presence of solvents.

P. S. Rege *and* T. S. Wheeler, Bombay.

In continuation of the work described last year, the benzoin reaction has been studied in the presence of diluents, like chloroform, carbon tetrachloride, pentane, *cylco*hexane, benzene, toluene, and their chloro-derivatives. The rate of the homogeneous autocatalyzed reaction has been found to decrease with increase in the amount of the solvent. Benzyl chloride shows the greatest inhibiting effect. The inhibition can be explained on the assumption that the trace of the cyanide dissolved in benzaldehyde, which is responsible for the autocatalyzed reaction, is precipitated by the solvent. Assuming that the heterogeneous reaction on the surface of the solid cyanide is unaffected, it has been found that the time-yield curves obtained with the inert solvents admit of a kinetic interpretation. Acetone has been found to accelerate the rate of the homogeneous reaction.

The reaction has also been studied in the presence of methyl and ethyl alcohols, ethylene glycol, and glycerol. Small quantities of these

alcohols gradually increase the rate of the reaction; larger ones delay the starting point of the accelerated reaction; whereas still larger quantities accelerate the reaction right from the beginning. Small quantities of polyhydric alcohols increase the rate of the reaction.

40. The thermal decomposition of mercurous nitrate.

M. S. Shah *and* B. G. Joshi, Ahmedabad.

The decomposition of hydrated and anhydrous mercurous nitrate has been studied quantitatively by heating the substance *in vacuo* and analyzing the solid and gaseous products. The monohydrate loses water and then behaves like the anhydrous salt. The latter becomes pale yellow at about 45° and decomposes below 100° evolving nitrogen peroxide and leaving a yellow residue of the composition: $HgNO_3$, 2HgO. On further heating up to 200° no change occurs, but above 200°, $HgNO_3$, 2HgO loses nitrogen peroxide and is converted into mercuric oxide. At any stage during decomposition if the system be allowed to cool down all nitrogen peroxide is reabsorbed forming mercurous nitrate, thus showing that the change is reversible.

41. The thermal decomposition of 'spent acetate of lime'.

Balwant Singh, Gurbachan Singh, *and* H. B. Dunnicliff, Lahore.

It has been found that calcium carbonate in spent acetate of lime is completely decomposed into calcium oxide when heated for half an hour at 900°C. In a current of air, quantitative decomposition took place at 700°C. to 720°C. and, in the presence of steam, at about 660°C. in the same interval of time. The spent acetate of lime, when heated at 650–700°C. mixed with 10% carbon, gave a quantitative yield of calcium oxide in 30 minutes. In a current of air and steam the calcium carbonate in the spent acetate mixed with carbon was decomposed completely at 600–620°C. in half an hour.

42. A potentiometric study of some oxidation-reduction reactions.

Balwant Singh, Ijaz Ilahi, *and* H. B. Dunnicliff, Lahore.

Oxidation with potassium iodate:—Potassium iodate has been used as an oxidizing agent in the potentiometric estimation of antimonite, arsenite, dichromate, permanganate, tetrathionate, in ferrous, stannous, mercurous, and thallous salts and in hydrazine sulphate by Andrew's method. The concentration of hydrochloric acid was kept between 4–5 *N* in these titrations.

Oxidation with chloramine-T:—Potassium iodide and sodium sulphite have been determined by titrating them potentiometrically against a standard solution of chloramine-T.

Reduction with sodium sulphite:—Sodium sulphite has been used as a reducing agent in acid solution in the presence of an excess of potassium iodide to determine iodine, potassium dichromate, potassium ferricyanide, hydrogen peroxide, and copper sulphate by the potentiometric method.

43. The influence of sorbed oxygen and nitric oxide on the retention of carbon monoxide and sulphur dioxide by charcoal.

M. S. Shah *and* S. G. Sharangpani, Ahmedabad.

The adsorption of carbon monoxide and sulphur dioxide has been studied at 0° on purified sugar charcoal (*a*) exhausted at 900°, (*b*) containing

sorbed oxygen, and (*c*) containing sorbed oxygen and nitric oxide. From the results of analysis of the gases pumped off at 0° and on subsequent heat treatment of charcoal in vacuo to 170° and 900°, it is observed that with charcoal in (*a*) and (*b*) both carbon monoxide and sulphur dioxide are completely removed as such on desorption at 0° and at 0° and 170° respectively, while with charcoal in (c) the retention of a part of both these gases takes place. Carbon monoxide thus retained at 0° is evolved in the form of carbon dioxide on raising the temperature to 170°, whereas sulphur dioxide is given out along with the gas coming off at 900°. It appears that both carbon monoxide and sulphur dioxide thus retained are oxidized, by sorbed oxygen and nitric oxide on the surface of charcoal, to carbon dioxide and sulphur trioxide respectively. The former is evolved as such, while the latter gets reduced by charcoal when the temperature is raised and hence is found as sulphur dioxide.

44. Heats of adsorption of nitric oxide on charcoal (*a*) exhausted at 900°, (*b*) containing sorbed oxygen, and (*c*) containing sorbed oxygen and nitric oxide.

M. S. SHAH *and* S. G. SHARANGPANI, Ahmedabad.

In continuation of the previous work (*Proc. Ind. Sc. Cong.*, 1934, p. 211) the authors have conducted experiments for the accurate measurements of—

(I) the heats evolved during the adsorption of nitric oxide at 0° and 1 A.P. for a period of 24 hours on purified sugar charcoal (*a*) exhausted at 900°, (*b*) containing sorbed oxygen derived from nitric oxide treatment in (*a*) followed by evacuation at 170°, and (*c*) containing sorbed oxygen and nitric oxide derived from the system in (*a*) on evacuation at 0°, and

(II) the heats absorbed during the desorption of each of the systems (*a*), (*b*), and (*c*) in (I).

From the analytical results of the gases pumped off at 0° and the values of the heats absorbed during desorption in (II), together with the fact that carbon dioxide and nitrogen are completely desorbed from the system at 0° (Shah and Sharangpani, *loc. cit.*), the heats of adsorption of nitric oxide per gram molecule on the surface of charcoal in (*a*), (*b*), and (c) are calculated and found to be 7513, 9605, and 1773 calories respectively.

45. On the effect of addition of mineral acids on the surface tensions of soap solutions.

A. NAGARAJA RAO, Bangalore.

The influence of different salts on the detergent properties of soaps has already been investigated by different workers, and the detergent action of soaps has been explained as being due to the lowered surface tensions of soap solutions when compared to water, which makes it possible for the dirt to get into the foam exactly as in the flotation process of ore concentration. The liberation of small quantities of the OH′ by the hydrolysis of the soaps (*pH* thereby getting higher than 7) is also explained to exert its own influence in the detergent action.

The addition of mineral acids, by pushing back the hydrolysis of soaps and by suitably varying the Ph value of the medium, exerts its definite influence in the variation of the detergent action, which is here measured by the variation of the surface tensions of soap solutions with the nature and concentration of the soap, and the nature and concentration of the mineral acid added.

46. The conductivity of pure soaps in ethyl alcohol and ethyl alcohol-water mixtures.

B. S. V. K. VITTAL *and* S. K. K. JATKAR, Bangalore.

Continuing the previous work (*Proc. Ind. Sci. Con.*, Allahabad, 1930), the study of the conductivity of soaps in alcohol-water mixtures has revealed the marked influence of the addition of small amounts of water. The solutions exhibited a minimum depending upon the dilution, Walden's rule being approximately obeyed. The effect of viscosity and dielectric constants of the solvent cannot quantitatively account for the results observed. The plot of conductivity against all suggested methods of calculations always exhibits a maxima or minima, and in some solutions both, although at higher concentrations they all yield flat straight lines. The behaviour observed is in agreement with the idea that in alcohol-water mixtures soaps behave as weak electrolytes.

47. The conductivity of benzoic acid in the presence of some chlorides in aqueous solutions.

S. S. JOSHI *and* D. N. SOLANKI, Benares.

The problem arose through finding in these laboratories that the partition coefficient, $C\omega/C_T$ (where $C\omega$ and C_T denote respectively the concentration of benzoic acid distributed between water and the toluene phase) usually diminished due to additions of electrolytes to the aqueous phase. Determinations were, therefore, made of the influence on the conductivity of benzoic acid solution on adding varying amounts of the chlorides of lithium, sodium, potassium, rubidium and cæsium, barium, mercury, and hydrochloric acid. The concentration of benzoic acid in each case was varied in the range $N/4$ to $N/400$. Except in the case of hydrochloric acid, the specific conductivities of the mixtures, especially for low proportions of the solute, were in excellent agreement with the mixture law. The possibility of the variation of the activity of the undissociated benzoic acid due to addition of the above substances is investigated.

48. The viscosity of mercuric chloride solutions at 35°.

BALBHADRA PRASAD, Cuttack.

The viscosity of mercuric chloride solutions has been measured at 35° by means of Ostwald Viscometer. The concentration ranged from very dilute solutions to almost saturated solutions. In solutions where concentration is greater than 0·4% (0·4 gms. dissolved in 100 c.c. of the solution) the viscosity concentration graph is almost linear. Thus with respect to viscosity also mercuric chloride in solution behaves more like a non-electrolyte than an electrolyte.

49. The variation of physical properties with changes in the concentration of HIO_3 solution.

M. R. NAYAR, Lucknow.

Experiments on freezing point depression, Raman spectra, etc. indicated polymerization of iodic acid in concentrated aqueous solutions. (*Zeit. anorg. Chemie.*, 1934, *220*, pp. 163–171). Confirmatory evidence is available from a systematic study of the various physical properties, such as density, freezing point depression, refractive index, viscosity, and surface tension of solutions varying from $5N$–$0{\cdot}01N$. The graphs connecting these properties with concentration are similar, and in no case is the additive law obeyed.

The graph of molecular viscosity ($\log V^{2/3}\eta - \log \text{conc}^{n}.$) is a straight line between $0{\cdot}01N$ and $0{\cdot}5N$, after which it rather abruptly changes direction.

Very instructive graphs are obtained for the other properties also.

50. The detergent action of soaps.

B. S. KULKARNI *and* S. K. K. JATKAR, Bangalore.

This paper gives the preliminary results obtained in the course of a comprehensive study of detergents and the detergent action now in progress in our laboratory. We have developed an accurate method of measuring the detergent action of pure soaps by measuring (1) the interfacial tension of benzene and soap solutions with an improved form of inverted pipette for counting the drop number, (2) the viscosities of the emulsions of benzene and water as a measure of adhesion tension, and (3) by the use of an inactive flocculated colloid like Fe_2O_3 instead of carbon black as ' ideal dirt '.

51. The detergency of soap solutions.

B. G. ACHARYA *and* T. S. WHEELER, Bombay.

In continuation of the work described last year, the maximum efficient adsorption, pH value, drop number, lathering and wetting powers of dilute soap solutions have been studied. The soaps examined include commercial household soaps, both foreign and Indian; soaps prepared from vegetable oils, and also sodium salts of pure fatty acids. The effect of the addition of various builders on those soaps has also been examined. From the relative adsorption of various soaps on yarn with reference to other properties mentioned, the necessary requirements for a good soap have been deduced. The adsorption value can be used for evaluating the detergency of soap solutions.

52. A lubrication apparatus.

A. NAGARAJA RAO, Bangalore.

The nature of surface films, and the orientation of the molecules in the adsorption layer, have at different times been studied by different investigators employing widely different methods. Hardy has utilized the values obtained for the sliding friction between surfaces to interpret the nature of contact between them, and also the nature and the thickness of the air-cushion separating them under widely different conditions. An apparatus has been constructed by the author for the determination of the sliding friction between different similar and dissimilar surfaces by a measurement of the limiting angle necessary to bring about the sliding of one surface against the other, and when in contact with different substances. The nature of the surface, the material adsorbed, and the extent of adsorption appear to be the chief factors affecting the limiting angle of sliding. The question of the smoothness of different surfaces, however, also makes the values obtained with different surfaces not easily comparable.

It is expected that this apparatus could be made to yield, in the case of lubricants, values which bear a direct relationship to the lubricating property, so that it would be an easy matter to assess the relative efficiencies of different lubricants.

53. A valve potentiometer.

S. K. KULKARNI JATKAR *and* D. N. MEHTA, Bangalore.

Continuing previous work we have now constructed a three valve amplifier using an electrometer triode as the first stage, L_2 as second, and LP_2 as the last stage, the arrangement being sensitive to a microvolt using a ballistic mirror galvanometer.

54. A thermostat using a gas-filled valve relay.

S. K. KULKARNI JATKAR, Bangalore.

The usual trouble through the sticking of the electromagnetic relays for thermostats can be easily obviated by using the gas-filled relays which can be had for any rating of current. The author has designed a simple arrangement using such a valve.

55. The physical identity of enantiomers. Part III. Viscosities, densities, and refractivities of *d*-, *l*-, and *dl*-forms of *iso*nitrosocamphor (stable and unstable), camphor, camphoric acid, camphoric anhydride, camphorquinone, and sodium camphorate.

B. K. SINGH, KAILASHPATI NARAYAN, PARAMESHWAR SINHA, SHEONATH PRASAD, *and* NUTBEHARI CHATTERJI, Cuttack.

The viscosities, densities, and refractivities of *d*-, *l*-, and *dl*-forms of camphor and its several derivatives have been examined at 35° at several concentrations. It is found that these properties are identical for the *dextro* and *lævo* isomerides of these compounds: thus Pasteur's Law of Molecular Dissymmetry holds good for these scalar properties also.

The value of these properties for the racemic form of the above-mentioned compounds is different at higher concentrations, but identical at lower: thus indicating the existence of racemates in solution at certain concentrations. In dilute solutions, the racemate is completely dissociated into the optically active components.

The stable (m.p. 153-154°) and the unstable form (m.p. 114-115°) of *iso*nitrosocamphor have been allocated configurations from viscosimetric determinations (*cf.* Thole, *J. Chem. Soc.*, 1912, *101*, 552). The unstable form having the higher viscosity must have the configuration in which the carbonyl and the hydroxyl groups are opposed to each other, whereas the stable form is assigned the configuration in which these groups are adjacent.

ORGANIC CHEMISTRY.

56. On hydroxy-lactone tautomerism.

CHITTARANJAN BARAT *and* BASUDEB BANERJEE, Calcutta.

The existence of *ortho*-aldehydic and *ortho*-ketonic acids in the hydroxylactone forms has been proved by the formation of two different series of isomeric methyl esters obtained under different conditions, by various workers among whom the names of Meyer, Kirpal, Wegscheider and Goldschmidt may be mentioned. But so far very meagre attention has been given towards the existence of such forms in open-chain γ- and δ-ketonic acids. Experiments with δ-ketonic acids like β-phenyl-γ-benzoyl- and β-phenyl-γ-toluyl-butyric acids have proved the existence

of such a pair of tautomeric forms by the formation of two series of methyl esters under different working conditions. The pseudo esters, however, which are in reality the methyl ethers of the lactol forms, are less stable than the normal esters, and are easily convertible into the latter modifications by the action of strong acids and alkalies. The formation of internal anhydrides by the action of acetic anhydride upon these acids also speaks for the existence of these acids in the hydroxylactone forms.

57. Studies in optical isomerism. Part I. Preparation of dextro-*m*-nitrocinnamic acid dibromide.

P. RAMASWAMI AYYAR, Bangalore.

The dextro isomer $\left(\alpha_D^{28^\circ} = +8{\cdot}13^\circ \text{ in methyl alcohol}\right)$ has been prepared in 30 per cent. yield from inactive (*dl*) *m*-nitrocinnamic acid dibromide by fractional precipitation of the brucine salts.

58. Studies in steric hindrance. Part IX. Oxidative elimination of carboxyl group from 2 : 4 : 6-trinitrobenzoic acid with formation of picric acid (2 : 4 : 6-trinitrophenol).

J. D. VASAVADA *and* P. RAMASWAMI AYYAR, Bangalore.

Trinitrobenzoic acid on oxidation with potassium permanganate in acetone solution yields about 15 per cent. of trinitrophenol, identified as such and also by the preparation of acenaphthone picrate. Similar oxidation of 2 : 4- and 2 : 6-dinitrobenzoic acids is in progress.

59. Isomerism of acetonedicarboxylic anhydride.

R. P. KANSHAL *and* S. S. DESHPANDE, Indore.

Pechmann and Neger obtained from acetic anhydride and crude acetonedicarboxylic acid containing a little sulphuric acid dehydracetonecarboxylic acid. Willstatter used pure acetone dicarboxylic acid and obtained its anhydride which melts at 147°, which is the melting point of the acid itself. We repeated Willstatter's experiments, but could not get his anhydride. We got, however, another isomeric anhydride melting at 92°. This does not behave as a true anhydride. It dissolves in cold alkali from which it is precipitated unchanged by addition of acid. Its hot aqueous solution can, however, be titrated against alkali.

It is probably 2 : 6-dihydroxy pyrone, for like pyrones, it forms an addition product with mercuric chloride. Moreover, as in pyrones, its carbonyl group is unreactive, while that of the free acid is reactive. Towards aniline, however, it behaves as a true anhydride and gives an acid anilide.

60. The influence of α-phenyl group in three carbon tautomerism.

N. L. PHALNIKAR *and* K. S. NARGUND, Ahmedabad.

The object of the present work is to study the effect of α-phenyl group on the mobility and equilibrium in three carbon tautomerism, and compare it with that of α-methyl group already noted by Kon and Thakur (*J. Chem. Soc.*, 1930, 2217). The α-phenyl-αβ, βγ-unsaturated acids required for this work were prepared by the dehydration of the corresponding β-hydroxy esters obtained by the method of Ivanoff and

Nicoloff (*Bull. Soc. Chim.*, 1932, *51*, 1325). The study is at present limited to the following compounds :

α-phenyl-*cyclo*pentylidene-(*cyclo*pentenyl) acetic acid,
α-phenyl-*cyclo*hexylidene-(*cyclo*hexenyl) acetic acid,
α phenyl-$\Delta^{\alpha}(\Delta^{\beta})$-hexenoic acid.

Experiments on the equilibration of these acids under the standard conditions of Linstead and his co-workers are in progress.

61. Constitutions of phenylglutaconic acids and esters. Part I. α-Phenylglutaconic acid.

N. L. PHALNIKAR *and* K. S. NARGUND, Ahmedabad.

α-Phenylglutaconic acid has been synthesized by a special method (*Bombay Univ. Jour.*, 1935). It seems to be *trans* αβ-acid as it does not readily yield an anhydride and gives benzoic acid on oxidation by dilute potassium permanganate. Several functional derivatives such as silver, lead, and copper salts, anil, anilic acid, and anhydride have been prepared. The ethyl ester prepared through the silver salt gives a characteristic sodio derivative when treated with sodium ethoxide or molecular sodium. Experiments on methylation of the sodio derivative are in progress.

62. Reactivity of formic acid.

L. S. HEBLE *and* T. S. WHEELER, Bombay.

Previous work on the reactivity of formic acid on compounds containing a reactive halogen atom has been extended. The kinetics of the reaction of anhydrous formic acid with benzyl chloride has been worked out. The formates of sodium, potassium, and ammonium accelerate the reaction. The kinetics of the reaction with acid chlorides is now being studied.

63. Studies in chloralamides.

N. W. HIRWE *and* J. S. DESHPANDE, Bombay.

Amides of *o*-, *m*-, and *p*-toluic acids were condensed with chloral and the respective chloralamides [$R{\cdot}CO{\cdot}NH{\cdot}CH(OH)CCl_3$] obtained. Dimethylsulphate gave methoxy-derivatives, benzoyl chloride gave benzoyl derivatives and anhydro-compounds, acetic anhydride gave anhydro-compounds and acetyl-derivatives with alkali or concentrated H_2SO_4.

64. The reactivity of α-chlorine in chloralamides.

N. W. HIRWE *and* B. V. PATIL, Bombay.

Chloralamide derivatives of 3-bromo, 5-bromo, and 3 : 5-dibromo-salicylic acids and their methyl ethers on treatment with phosphorus pentachloride gave *α-chloro-derivatives* $RCONH{\cdot}OHCl{\cdot}CCl_3$ which react with water, methyl alcohol, ethyl alcohol, ammonia, aniline, *o*-, *m*-, and *p*-toluidines.

65. The reactivity of α-chlorine in chloralamides.

N. W. HIRWE *and* (MISS) K. D. GAVANKAR, Bombay.

Chloralamide derivatives of 3-nitro-, 5-nitro-, and 3 : 5-dinitrosalicylic acids and their methyl ethers on treatment with phosphorus pentachloride

gave α-*chloro*-derivatives [RCO·NH·CH(Cl)·CCl_3] which react with water, methyl alcohol, ethyl alcohol, ammonia, aniline, *o*-, *m*- and *p*-toluidines.

66. Oxidation of alcohols by means of nitrogen peroxide.

P. S. VARMA *and* C. SATYANARAYAN, Benares.

When methyl, ethyl, propyl, *iso*propyl, butyl, *iso*butyl, amyl, and *iso*-amyl alcohols are treated with nitrogen peroxide either alone or in presence of substances such as vanadium pentoxide, thorium oxide, cerium oxide and mercuric nitrate, alkyl nitrates are the main products obtained; but when these alcohols are brought in contact with nitrogen peroxide in the gaseous state, specially in presence of vanadium pentoxide, thorium oxide, cerium hydroxide, and mercuric nitrate, varying yields of the corresponding acids are obtained. Vanadium pentoxide gives the best yield of the acids, 85% from ethyl alcohol, 75% from propyl alcohol, 73% from *iso*propyl alcohol and *iso*butyl alcohol, 72% from butyl alcohol and 61% from normal primary amyl alcohol.

67. Studies on the addition of hydrogen halides to unsaturated conjugated systems.

S. N. GANGULI, Kasauli.

1. Addition of hydrogen bromide to butadiene leads to the production of 1 : 4-bromobutene-2 only.

2. Addition of hydrogen chloride to butadiene leads to the formation of two isomerides, namely (*a*) 1 : 4-chlorobutene-2 and (*b*) 1 : 2-chlorobutene-3.

The properties of these addition products have been compared with authentic specimens of the same prepared synthetically, in order to settle their constitution and thereby to locate the position of the new entrants.

An explanation has been advanced to interpret the results obtained in the light of the modern concepts of the electronic theory of valency.

68. The action of malonic ester upon *iso*propylidene malonic ester.

P. C. GUHA *and* V. K. SUBRAMANIAN, Bangalore.

Molecular proportions of sodio-malonic ester and *iso*propylidene malonic ester on being heated in a sealed soda water bottle at 150–60° for 24 hours yielded a product, the water soluble portion of which on acidification gave an oil. The aqueous sodium carbonate extract of the oil on acidification and purification by crystallization from alcohol gave a solid, m.p. 107°, identified to be phloroglucinol dicarboxylic ester.

From the residual oil after sodium carbonate treatment, *iso*propylidene dimalonic ester could be smoothly distilled. Action of alkylene dihalides on the disodium and magnesium derivative of *iso*propylidene dimalonic ester is under investigation.

69. On cyclization of methylene dimalonic ester.

P. C. GUHA *and* V. K. SUBRAMANIAN, Bangalore.

Methylene dimalonic ester (1 mol.) on being heated on a water-bath for 4 hours with alcoholic sodium ethoxide (1·2 mol.), and the product being worked up, gave an ester, b.p. 115–18°/3 mm. It gives colouration with ferric chloride and a solid derivative with phenylhydrazine. Work is in progress to elucidate the structure of the compound.

70. Halogenation. Part XIX. The effect of ultraviolet light on the halogenation of some aromatic hydrocarbons.

P. S. VARMA *and* R. PICHAI, Benares.

Benzene, toluene, *o*-xylene, *m*-xylene, *p*-xylene and pseudocumene have been brominated in ultraviolet light either alone or in presence of halogen carriers such as aluminium-mercury couple, pyridine, iodine, iron filings, red phosphorus, aluminium chloride, etc., additive as well as substitution products—substitution in the side-chain as well as nucleus —have been obtained in varying yields.

71. Halogenation. Part XVIII. Bromination of toluene.

P. S. VARMA *and* A. KRISHNAMURTHY, Benares.

Bromination of toluene has been carried on exhaustively in sunlight alone, or in sunlight in the presence of substances such as aluminium dust, aluminium chloride, aluminium-mercury couple, stannic chloride, lanthanum chloride, yttrium chloride, zirconium oxide, thorium chloride, cerium chloride, lead peroxide, red and yellow phosphorus, phosphorus tribromide, vanadium trichloride, yellow sulphur, selenium, tellurium, uranium nitrate, molybdic acid, manganese chloride, potassium permanganate, chromic oxide, iodine, nickel bromide, palladium chloride, iron dust, ferric chloride, and ferric bromide. In accordance with the effect produced on bromination, the above substances can be divided into four classes :

(i) those that have no effect on bromination at all, i.e. the products obtained being the same as those obtained in sunlight alone;
(ii) those that yield only *p*-substituted nuclear compounds with a certain quantity of the side-chain substituted halogen derivatives;
(iii) those that yield both *o*- and *p*-substituted nuclear compounds only, the *p*-substituted derivative predominating in some cases and the *o*-substituted in others;
(iv) those that yield both *o*- and *p*-substituted nuclear derivatives as well as side-chain substituted ones.

72. Bromination of substances containing two aromatic nuclei. Part III. Bromination of substituted phenyl salicylates.

Y. I. RANGWALA *and* G. V. JADHAV, Bombay.

In continuation of previous work (*Proc. Ind. Acad. Sciences*, 1935, *1*, 616, and *J. Indian Chem. Soc.*, 1935, *12*, 89) *p*-cresyl salicylate, *p*-nitrophenyl salicylate, and *p*-chloro-phenyl salicylate were prepared and brominated. The brominated compounds were purified and found identical with *p*-cresyl-5-bromo-salicylate (m.p. 96–99°), *p*-cresyl 3 : 5-dibromo-salicylate (m.p. 151°), *p*-nitro-phenyl-5-bromo salicylate (m.p. 213°) and *p*-chloro-phenyl-5-bromo salicylate (m.p. 102–104°). The above esters were prepared for identification from 3-bromo-and 3 : 5-dibromo salicylic acid and the different cresols and phenols. The above results show the strong directing influence of the OH group in the salicylic acid nucleus over that of CH_3 and Cl group apart from the deactivation caused by the presence of the nitro group in *p*-nitrophenylsalicylate.

73. o-Aldehydo-carboxylic acids. Part III. A synthesis of 4 : 5-methylene-dioxyphthalaldehydic acid.

S. N. CHAKRAVARTI *and* M. SWAMINATHAN, Annamalainagar.

4 . 5-Methylenedioxyphthalaldehydic acid, for the synthesis of which an unsuccessful attempt was made in 1927 by Stevens and Robertson (*J. Chem. Soc.*, 1927, 2791), has now been synthesized from 4 : 5-methylenedioxyhomophthalic acid, which in its turn was prepared from piperonal through the corresponding hydrindone. 4 : 5-Methylenedioxyhomophthalic acid on oxidation with selenium dioxide in benzene solution gave the corresponding phthalonic acid, the anilino derivative of which on being boiled with dry xylene was transformed into anilo-4 : 5-methylenedioxyphthalaldehydic acid, m.p. 187°. The latter on hydrolysis gave 4 : 5-methylenedioxyphthalaldehydic acid, m.p. 167°. The aldehydo-acid on reduction with sodium amalgam gave 4 : 5-methylenedioxyphthalide, m.p. 189°, which was also obtained by decarboxylating 4 : 5-methylenedioxyphthalidecarboxylic acid, m.p. 223°, obtained by the reduction of 4 : 5-methylenedioxyphthalonic acid.

74. On some polybasic acids.

P. K. PAUL, Calcutta.

The following experiments were performed in order to prepare some intermediate products which were required in a scheme of synthesis of cochinellic acid.

m-Cresol was condensed with chloroform in presence of caustic soda solution giving rise to 2-hydroxy-4-methyl benzaldehyde (b.p. 219°–221°) which was methylated with methyl iodide. The 2-methoxy-4-methyl benzaldehyde (b.p. 250°–253°), thus obtained, was condensed with malonic acid to yield the corresponding cinnamic acid derivative (m.p. 211°-212°). This was then reduced to the hydrocinnamic acid derivative (m.p. 95°).

The constitution of 2-methoxy-4-methyl-benzaldehyde has been verified by its synthesis from methoxy-*m*-cresotinic acid, which was in turn converted into the amide (m.p. 143°)—nitrile (m.p. 71°)—aldehyde (b.p. 251°-252°) and cinnamic acid (m.p. 211°-212°).

75. The synthesis of coumarins and chromones from phenols and β-ketonic esters: Coumarins and chromones from 4-chloro-1-naphthol.

D. CHAKRAVARTI *and* P. BAGCHI, Calcutta.

In view of the work of Dey and Laksminarayanan (*J. Indian Chem. Soc.*, 1932, *9*, 153), who obtained a chromone by condensing β-naphthol with acetoacetic ester using H_2SO_4 as condensing agent, and the observations of one of us (Chakravarti, *J. Indian Chem. Soc.*, 1932, *9*, 32) that chloro-, bromo-, and nitro-phenols yield chromones according to Simonis' method using phosphorus pentoxide, the condensations of the halogenated and nitronaphthols (α- and β-) with β-ketonic esters have been studied.

4-Chloro-1-naphthol (Kast, *Ber.*, 1911, *44*, 1337) has been condensed with acetoacetic ester and its C-alkyl derivatives using sulphuric acid (Pechmann's reaction) or phosphorus pentoxide (Simonis' reaction). In the presence of sulphuric acid coumarins are always formed, but the yield diminishes markedly with a heavier substituent in the acetoacetic ester molecule. When phosphorus pentoxide is used 4-chloro-1-naphthol gives coumarins with unsubstituted acetoacetic ester, but C-methyl-, C-ethyl-, and other C-alkyl-acetoacetic esters give a good yield of chromones forming characteristic styryl derivatives.

76. Preparation of higher fatty-acyl derivatives of α-naphthylamine.

P. S. VARMA *and* C. SRINIVASMURTHYACHAR, Benares.

Attempts have been made with success for the preparation under ordinary conditions of caproic, caprylic, lauric, myristic, palmitic, and stearic acid derivatives of α-naphthylamine which have been obtained before by heating at high temperatures in sealed tubes.

77. Studies in the chemistry of amidines.

A. P. KHANOLKAR *and* T. S. WHEELER, Bombay.

By condensing benzotrichloride with *m*-toluidine in nitrobenzene, *di-(m-tolyl)-benzamidine* was obtained. With chloroformic ester it gave a *product* of the formula $C_6H_5C(:NC_6H_4CH_3)(\cdot NC_6H_4CH_3)(COOEt)$. Di-(*m*-tolyl)-benzamidine, di-(*p*-nitro-phenyl)-benzamidine and di-(*m*-nitrophenyl)-benzamidine were methylated and *methyl derivatives* obtained.

On oxidation, diphenyl-benzamidine gave a compound of the constitution $[C_6H_5C(:NC_6H_5)(\cdot NC_6H_5)]2$.

*N'-(*p*-nitro-phenyl)-N-(*p*-methoxy-phenyl)-benzamidine, N'-(di-*m-p*-methyl-phenyl)-N-(*p*-nitrophenyl)-benzamidine, N'-(*m*-nitrophenyl)-N-(*p*-nitro-phenyl)-benzamidine* have been prepared. The tautomerism of the amidines is being studied.

78. Studies in the chemistry of amidines.

S. P. JOSHI *and* T. S. WHEELER, Bombay.

(1) Di-(*p*-chloro-phenyl)-benzamidine, (2) N'-(*p*-chloro-phenyl)-N-(phenyl)-benzamidine, (3) N'-(*p*-ethoxy-phenyl)-N-(*p*-chloro-phenyl)-benzamidine, have been prepared and methylated. Indication of the formation of two methyl derivatives has been obtained with (2) and (3). The tautomerism of other unsymmetrical amidines is being investigated.

79. Styryl-amidines.

R. C. SHAH *and* M. M. SIDIKI, Bombay.

As styryl-amidines have not hitherto been prepared, a number of typical styryl-amidines, which were also required in connection with other work, have been prepared for an examination of their chemical properties by condensation of cinnamanilides with arylamines in the presence of phosphorus trichloride. The following amidines have been obtained: Diphenylcinnamamidine, phenyl-*p*-tolyl-cinnamamidine, phenyl-*o*-tolyl-cinnamamidine, phenyl *m*-tolyl-cinnamamidine, phenyl-*p*-methoxy-phenyl-cinnamamidine, phenyl-*p*-ethoxy-phenyl-cinnamamidine, Di-(*p*-methoxyphenyl) cinnamamidine, di-(*p*-ethoxy phenyl) cinnamamidine. All the amidines are yellow crystalline solids. Some reactions of the amidines including bromination and reduction have been studied.

80. Imido-chlorides. Condensation of *N*-phenylurethane with benzanilideimidochloride.

R. C. SHAH *and* H. P. GHADIALI, Bombay.

Benzanilideimido-chloride, when condensed with the sodium derivative of *N*-phenylurethane in ethereal medium, gave the condensation product phenyliminobenzyl-*N*-phenyl urethane, m.p. 86°, whose constitution was proved by its synthesis from diphenylbenzamidine and ethyl chloroformate. Various reactions of the condensation product have been

studied. The action of bromine gave a dibromo addition product, and the action of aromatic amines gave characteristic derivatives. It is easily hydrolyzed by hydrochloric acid into benzanilide and phenylurethane. Reduction by aluminium amalgam yielded the reduction product, which is readily and smoothly hyrdolyzed to give benzaldehyde in almost theoretical yield. This provides a valuable new mothod for the conversion of an aromatic carboxylic acid into the corresponding aldehyde.

81. Imido-chlorides. Reactions of oxanilideimidochloride.

V. R. HEERAMANECK *and* R. C. SHAH, Bombay.

Oxanilide-imido-chloride was prepared according to the method of Bauer (*Ber.*, 1907, *40*, 2653). With aniline it afforded the corresponding diamidine, m.p. 156–158° (hydrochloride m.p. 242°). On condensation with ethylsodiomalonate in toluene, it gave the condensation product, m.p. 128–130°, which has been cyclized by the action of heat into 4 : 4′-dihydroxy-3 : 3′-dicarbethoxy-2 : 2′-diquinonyl, m.p. above 300°. Condensation with the sodium derivative of urethane, yielded a crystalline product, which is being investigated.

82. Condensation of epichlorhydrin with resacetophenone.

D. R. NADKARNI *and* T. S. WHEELER, Bombay.

In continuation of the work with glyceryl chlorhydrin described last year, the above condensation was investigated and found to give three *ethers* under suitable conditions: chlorhydrin ether, mono-glycide ether, di-glycide ether. The former two gave on hydrolysis the mono-ether obtained in the condensation of glyceryl chlorhydrin with resacetophenone. These ethers can be converted into one another under suitable conditions.

The *chalkones* obtained from the mono- and di-ethers from the latter condensation, gave on treatment with selenium dioxide *mono-* and *di-flavones*, while with hydrogen peroxide they gave *mono-* and *di-flavonols*.

83. Reactivity of *p*-anisylidene-*p*-methylacetophenone.

S. M. NADKARNI *and* T. S. WHEELER, Bombay.

The dibromide (II) of 4-methoxystyryl-*p*-tolylketone (I) gives when heated with methyl and ethyl alcohols α-*p*-toluoyl-α-bromo-β-4-methoxyphenyl-β-methoxyethane (III) and α-toluoyl-α-bromo-β-4-methoxyphenyl-β-ethoxyethane (IV) respectively. With excess of bromine, (I) yields the dibromide of 4-methoxy-3-bromo-styryl-*p*-tolylketone (V), which with methyl and ethyl alcohols gives respectively α-*p*-toluoyl-α-bromo-β-4-methoxy-3-bromo-phenyl-β-methoxyethane (VI) and α-*p*-toluoyl-α-bromo-β-4-methoxy-3-bromo-phenyl-β-ethoxyethane (VII). (V) with potassium iodide in acetone gives 4-methoxy-3-bromo-styryl-*p*-tolylketone (VIII) the constitution of which will be confirmed by its synthesis from 3-bromo-*p*-anisaldehyde and *p*-methylacetophenone. (II) with pyridine gives α-toluoyl-α-bromo-β-4-methoxyphenylethylene (IX) and it is also obtained by heating (III) or (IV). (V) with pyridine gives α-toluoyl-β-4-methoxy-3-bromophenylethylene (X) which is also obtained by heating (VI) or (VII). (II) and (V) with KCN in alcohol yield β-*p*-toluoyl-α-4-methoxyphenylpropionitrile (XI) and β-*p*-toluoyl-α-4-methoxy-3-bromophenylpropionitrile (XII) respectively. (XI) is also obtained from (I) and HCN.

84. Reactivity of piperonylidene-*p*-methyl-acetophenone.

A. M. WARRIER *and* T. S. WHEELER, Bombay.

The dibromide (I) of 3 : 4-methylenedioxystyryl-*p*-tolyl-ketone (II) when boiled with methyl and ethyl alcohols gives respectively, α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxyphenyl-β-methoxy-ethane (III) and α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxyphenyl-β-ethoxy-ethane (IV). With excess of bromine, (II) yields the dibromide of 3 : 4-methylenedioxy-6-bromo-styryl-*p*-tolyl ketone (V). This with methyl and ethyl alcohols gives respectively, α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxy-6-bromo-phenyl-β-methoxy-ethane (VI) and α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxy-6-bromo-phenyl-β-ethoxy-ethane (VII). (V) with potassium iodide in acetone gives 3 : 4-methylenedioxy-6-bromo-styryl-*p*-tolyl ketone (VIII), the constitution of which is fixed by its synthesis from 6-bromo-piperonal and *p*-methyl-acetophenone. (I) and (V) with pyridine give respectively, α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxyphenyl-ethylene (IX) and α-*p*-toluoyl-α-bromo-β-3 : 4-methylenedioxy-6-bromo-phenyl-ethylene (X). (X) is also obtained from (V) by the action of one molecule of sodium methylate. (I) and (V) with KCN in alcohol yield respectively, α-3 : 4-methylenedioxyphenyl-β-*p*-toluoyl-propionitrile (XI) and α-3 : 4-methylenedioxy-6-bromo-phenyl-β-*p*-toluoyl-propionitrile (XII). (XI) has been synthesized from (II) and HCN.

85. Condensation of phenols with succinic anhydride.

J. D. RAVAL *and* K. S. NARGUND, Ahmedabad.

Various phenols have been condensed with succinic anhydride by Friedel and Craft's method using acetylene tetrachloride as the solvent.

Phenol gave γ-keto-γ : 2-hydroxy-phenyl-butyric acid, m.p. 146°, identical with the acid described by Rosenmund and Schapiro (*Arch. Pharm.*, 1934, 313).

o-Cresol gave two products: (i) γ-keto-γ : 2-hydroxy-3-methyl-phenyl-butyric acid, m.p. 136°, (ii) γ-keto-γ : 4-hydroxy-5-methyl-phenyl-butyric acid, m.p. 184°.

m-Cresol gave γ-keto-γ : 2-hydroxy-4-methyl-phenyl-butyric acid, m.p. 154°.

p-Cresol gave γ-keto-γ : 2-hydroxy-5-methyl-phenyl-butyric acid, m.p. 137°, identical with the acid described by Rosenmund and Schapiro (*loc. cit.*).

The constitutions of the above keto acids were determined by first converting the phenolic group into the methoxy group and then oxidizing the methoxy compound. All the acids were characterized by the preparation of derivatives, such as methyl ester, ethyl ester, phenylhydrazones, etc. Further work on the condensation of substituted phenols and naphthols is in progress.

86. Condensation of nitro-phthalic anhydrides with phenol and anisole. Part II.

P. C. MITTER *and* P. C. DATTA, Calcutta.

3-Nitrophthalic anhydride condenses with phenol, in presence of aluminium chloride, giving 3-nitro-2 (2′-hydroxybenzoyl)-benzoic acid. (*Proc. Indian Science Congress*, 1935, p. 154.) Curiously enough, 4-nitrophthalic anhydride could not be condensed with phenol under the same conditions.

3-Nitrophthalic anhydride condensed readily with anisole, giving two products, among which 3-nitro-2 (4′-methoxybenzoyl)-benzoic acid predominates. With 4-nitrophthalic anhydride and anisole a mixture of

4-nitro-2 (4′-methoxybenzoyl)-benzoic acid and 5-nitro-2 (4′-methoxybenzoyl)-benzoic acid is obtained in almost equal quantities. On reduction, followed by diazotisation and ring closure and subsequent demethylation, the nitro-benzoyl benzoic acids gave 2 : 6 and 2 : 7 dihydroxyanthraquinones respectively.

87. Studies in the *iso*flavone series.

P. C. Mitter *and* S. S. Maitra, Calcutta.

Attempts at conversion of 2′-4′-dimethoxyphenyl-2 : 4 : 6 trihydroxyacetophenone (*Proc. Indian Science Congress*, 1935, p. 153) into *iso*flavone by treatment with ethyl formate and molecular sodium failed. On heating with sodium acetate and acetic anhydride, followed by hydrolysis, we obtained 2-methyl-5 : 7-dihydroxy-2′ : 4′-dimethoxy-*iso*flavone, m.p. 213-214°.

88. Condensation of bromo-salicylaldehydes with phenols and amines.

K. S. Venkat Raman *and* P. S. Varma, Benares.

The condensation of aldehydes with phenols has been previously studied by several investigators. By condensing 1 molecule of the aldehyde with 2 molecules of the phenols in presence of sulphuric acid (d. 1·840) at about 100°, Sen and Sinha (*J. Amer. Chem. Soc.*, 1923, 2984) obtained the corresponding fluorones at one stage. In the present paper 5-bromo-, 3 : 5-dibromo-, and 3-bromo-5-nitro-salicylaldehydes have been condensed with various phenols like resorcinol, pyrogallol, etc. and phenolic acids like gallic acid according to the above method. The condensation products are generally fluorescent and possess dyeing properties. These products on bromination yield compounds which are much deeper in colour.

The above aldehydes have been condensed with 2 molecules of dimethyl- and diethyl-anilines in presence of fused zinc chloride or concentrated hydrochloric acid to yield triphenylmethane dyes. The leuco bases are green in colour and these on oxidation give green dyes.

89. The condensation of aldehydes with malonic acid in the presence of organic bases. Part IV. The condensation of piperonal and the formation of piperonal-acrylic acid.

K. C. Pandya *and* T. A. Vahidy, Agra.

In the studies of the condensation of piperonal with malonic acid in the presence of traces of pyridine, the yield of the unsaturated acid was found to be theoretical (Kurien and Pandya, *J. Indian Chem. Soc.*, 1934, *11*, 825). The condensation has now been investigated in the presence of a large number of organic bases and also of ammonia and ammonium malonate (Knoevenagel). The organic bases tried were: aniline ; *o*-, *m*- and *p*-toluidine : α- and β-naphthylamine ; piperidine, methylaniline, ethylaniline, diphenylamine ; pyridine, lutidine, quinoline, *iso*quinoline, quinaldine, diethylaniline, and dimethylaniline. In every case the base was 0·15 molecular proportion, this being increased to 0·25 mole also in the case of piperidine. Good yields, up to 97%, were obtained. The piperonylacrylic acid, even after repeated purifications, melted at 242° (decomp.), and its identity was confirmed by analysis. The m.p.s recorded by earlier workers were lower (*cf.* 232°, Lorenz, *Ber*, 13, 757; 238°, Perkin, *J. Chem. Soc.*, 1891, 152; 232°, Dutt, *J. Indian Chem. Soc.*, 1925, *1*, 300; 240°, Kurien, *loc. cit.*).

90. Interaction of sulphuryl chloride with compounds containing two aromatic nuclei.

D. R. SUKHATANKAR *and* G. V. JADHAV, Bombay.

The work described last year (*Proc. Ind. Science Congress*, 1935, p. 136) has been extended to the benzoyl derivatives of *p*-phenetidine, *p*-anisidine, *m*-xylidine, and naphthylamines.

Sulphuryl chloride acts as the chlorinating agent in each case and chlorine enters the basic nucleus. The nitro benzoyl derivatives of *o*-, *m*-, and *p*-toluidines have also been investigated with similar results.

91. Derivatives of hydroxy-naphthoic acid.

S. N. RAO *and* G. V. JADHAV, Bombay.

Extending the work previously communicated, chlorination and bromination of 1-methoxy-2-naphthoic acid was carried out. The constitutions of the resulting products have been established and a number of derivatives prepared.

Bromination of the arylamides of 1-hydroxy-2-naphthoic acid was carried out in stages when mono- and dibromo compounds were obtained. The constitutions of these compounds have been confirmed by synthesis.

92. Action of hydrogen sulphide on chalcone oxides.

MISS B. N. KATRAK *and* T. S. WHEELER, Bombay.

When chalcone oxides are heated with H_2S, the oxide ring is opened and hydroxy-mercaptan derivatives are formed. An examination of the products obtained in this way from a number of chalcones is in progress.

93. Chalkones and flavones from 2-acetyl-resorcinol.

I. Z. SAIYED *and* T. S. WHEELER, Bombay.

2-Acetyl-resorcinol has been condensed with benzaldehyde, salicylaldehyde and *o*-chloro-benzaldehyde in presence of alkali. The condensation products are mixtures of chalkones and flavanones. The condensation of acetyl-β-methyl-umbelliferone with various aldehydes is also being examined.

94. Additive compounds of chlor-acetic acids with a few amines.

K. S. VENKAT RAMAN, Benares.

When warm benzene solutions of *o*-chloro-aniline, *p*-chloro-aniline, and β-naphthylamine are treated with mono-, di-, and trichloracetic acids in the same solvent and allowed to cool, needle-shaped crystalline additive compounds are obtained. The readiness with which the pure additive products could be prepared and their sharp m.p.'s make them useful for the identification of these amines. All the compounds are white turning grey on exposure for a long time, difficultly soluble in the ordinary solvents, easily soluble in alcohol and water. Strong alkalis generate the respective bases.

95. The reactivity of conjugated systems. Part VII. Condensation of 1 : 2-diketones with cyanoacetamide.

CHITTARANJAN BARAT *and* BASUDEB BANERJEE, Calcutta.

This type of reaction has not been undertaken so far, except in the case of benzil (MacRae and Kuchnern, *J. Amer. Chem. Soc.*, 1930, *52*,

3379), where the absence of a labile hydrogen atom precludes the formation of an enolic phase, and consequently it reacts purely in the ketonic form in the usual way.

In the course of the present work the condensation has been carried out with such 1 : 2-diketones that possess an enolic phase, e.g. *o-cyclo*-hexane- and *o-cyclo*-pentane-dione, diacetyl, etc. The reaction proceeds in the manner described in earlier works of this series, the ethylenic linkage getting preference over the ketonic, such that the primary addition takes place at the ethylenic bond followed by the elimination of water between the enolic hydroxyl and the amino groups. That one of the ketonic groups is left intact is proved by the formation of semicarbazones from the condensation products. The work has also been extended towards *ortho*-quinones, e.g. phenanthraquinone, acenaphthaquinone, etc. Here, however, the condensation takes place through the ketonic groups only for reasons stated above.

96. Studies in bridge formation.

P. C. GUHA, Bangalore.

The bridging of succinosuccinic ester with methylene iodide and ethylene bromide was first tried by Baeyer (*Ber.*, 1892, *25*, 2123), evidently without success.

Dry sodio-derivative of succinosuccinic ester when boiled under reflux during 72 hours with ethylene and trimethylene bromide yields the expected bridged compounds, m.p. 112° and 132°. That the reactions have not taken place in the enolic phase is proved by the fact that the bridged compounds give disemicarbazones. The bridged esters are easily hydrolysed by boiling with 50% HCl. It is interesting to note that the bridged diesters cannot be easily decarboxylated, and this behaviour is in marked contrast to that of succinosuccinic ester which gives 1 : 4-diketohexamethylene on being heated with water at 200°.

The compound obtained by the action of iodine or bromine on succinosuccinic ester and to which a bridged structure was given before (Gaind and Guha, *Sci. Cong. Abstracts*, 1934) has been proved to be dihydroxy terphthalic ester. This observation is important because it proves the instability of Dewar's structure of benzene which immediately on formation by the present method rearranges into the ordinary Kekule phase (*cf.* Ingold, *J. Chem. Soc.*, 1922, *121*, 1135).

Tetramethyl- and dimethyl-succinosuccinic esters are being prepared by the action of sodium on asym-dimethyl- and monomethyl-succinic esters which are expected to yield interesting bridged compounds.

97. Synthetic experiments in the pinene group. Part I. Synthesis of *cis*pinononic acid and ketonopinone (4 : 6-diketonopinane).

P. C. GUHA *and* K. GANAPATHI, Bangalore.

A series of synthetic experiments starting from norpinic acid have been instituted with the object of synthesizing pinene and its important degradation products. *Trans*-norpinic acid, obtained by the method of Kerr with slight modifications, is converted by means of acetic anhydride into *cis*-norpinic anhydride which with an equimolecular quantity of sodium methoxide gives the sodium derivative of *cis*-norpinic acid monomethylester. The acid chloride of this acid ester, prepared by treatment with thionyl chloride, furnished with zinc methyliodide *cis*-methylpinononate and a small amount of a solid, m.p. 72–74°. The ester on hydrolysis yields *cis*-pinononic acid.

Methyl pinononate on treatment with sodium in toluene solution or sodium ethoxide in alcoholic solution smoothly undergoes cyclization yielding 'ketonopinone' (4 : 6-diketonopinane) which exhibits all the properties of a β-diketone and gives a copper derivative. The constitution of this compound is confirmed by hydrolyzing it to pinononic acid with baryta. Work is in progress for the reduction of this diketone to nopinone and nopinane. This is the first total synthesis of a bicyclic compound of the pinene series.

98. Synthetic experiments in the pinene group. Part II.

P. C. GUHA *and* K. GANAPATHI, Bangalore.

As an alternative route to ketonopinone, *cis*-norpinic acid diethyl ester is condensed with ethyl acetate in presence of sodium whereby an oil, b.p. 66-67°/6 mm., and an undistillable product are obtained, the former exhibiting properties of a β-ketonic ester.

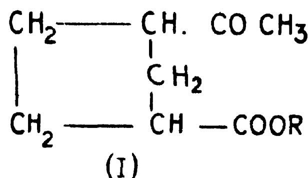
The synthesis of *cis*-4 : 4-dimethyl-1 : 3-diacetyl*cyclo*butane, which on dehydration is expected to yield verbenone, has not so far been achieved from *cis*-norpinic diacid chloride by the action of either MgMeI or ZnMeI. In the former case, an undistillable neutral product with a strong terpene-like odour and in the latter a neutral (probably a lactonic) product crystallizing in needles, m.p. 96°, together with an oil were obtained, none of which gave semicarbazones.

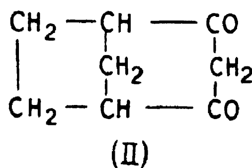
Another synthesis of nopinone through the following steps is in progress: *cis*norpinic anhydride→ethyl norpinylmalonate→pinylmalonic acid→*unsym.* homopinic acid→nopinone.

99. Bicyclo-(1 : 2 : 3)-octane-2 : 4-dione.

P. C. GUHA *and* S. K. RANGANATHAN, Bangalore.

Semmler and Bartelt's (*Ber.*, 1907, *40*, 4596) 1-acetyl*cyclo*pentane-3-carboxylic acid (I, R=H) obtained by oxidizing santene has been synthesized starting from *cis-cyclo*pentane-1 : 3-dicarboxylic anhydride. The great difficulty attending the preparation of the starting material by the older methods has been overcome by subjecting the cyclic tetra-ester to the action of 50% hydrochloric acid resulting in the formation, in one stage, of *cis* and *trans* diacids.





The monoacid monomethyl ester obtained from the *cis* anhydride by the action of methyl alcohol gives the corresponding acid chloride (*p*-toluidide, m.p. 118·5°) which furnishes the ketonic ester (b.p. 99-100°; I, R=CH_3; semicarbazone, m.p. 138°) on treatment with ZnMeI. The acid (I, R=H) boils at 145°/3 mm. (semicarbazone, m.p. 169°). The acid is identical with Semmler and Bartelt's compound.

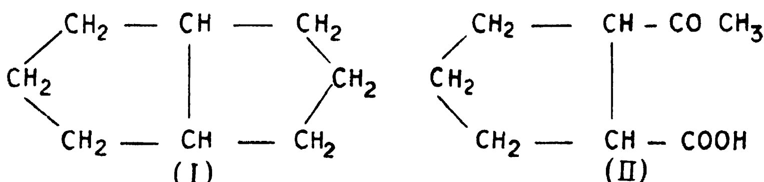
Various experiments were conducted with a view to obtain the interesting diketone (II) from (I, R=CH_3). The ester seems to be fairly stable to the action of sodium in benzene or ether solution, but in alcoholic solution, along with the acid (I, R=H) which is the main product, a small amount of the diketone (m.p. 123·5°) is formed which with semicarbazide gives a solid, m.p. 224°.

Experiments are in progress towards obtaining (II) in sufficient amounts to reduce it to homo-*nor*camphor.

100. Experiments towards the synthesis of bicyclo-(0 : 3 : 3)-octane. A synthesis of 1-acetyl-*cyclo*pentane-2-carboxylic acid.

P. C. GUHA *and* S. K. RANGANATHAN, Bangalore.

With the object of synthesizing derivatives of the bicyclic compound (I), *cis*-1-acetyl-*cyclo*pentane-3-carboxylic acid (II) has been synthesized as follows :



Perkin's pentane-1 : 1 : 5 : 5-tetracarboxylic ester (*J. Chem. Soc.*, *51*, 244) was prepared according to the improved method of Guha and Seshadriengar (*Current Science*, 1934, *3*, 21), b.p. 196–202°/4 mm. The ester is smoothly cyclized with bromine to give a good yield of the pure ring tetraester, b.p. 175–180°/4 mm. The *ciscyclo*pentane-1 : 2-dicarboxylic anhydride was obtained from this after the method of Perkin. The monoacid monomethyl ester gives the anhydride when distilled; the monoacid chloride boils at 107°/4 mm. The ketonic ester corresponding to acid (II) was obtained from it with ZnMeI (b.p. 94°/3-4 mm. ; semicarbazone, m.p. 146°). The acid (II) boils at 142°/3 mm. (semicarbazone, m.p. 176°).

Komppa and Rohrmann's (*Annalen*, 1934, *509*, 259) reaction on the anhydride gave only a small amount of a lactone b.p. 143-145°/25 mm. but not the expected ketonic acid (II).

Experiments are in progress to effect ring closure of the ketonic ester corresponding to the acid (II).

101. Work on the synthesis of thujane skeleton.

P. C. GUHA *and* S. K. RANGANATHAN, Bangalore.

Ciscyclo propane-1 : 2-dicarboxylic anhyride has been prepared with a view to convert it into bi*cyclo*-(0 : 1 : 3)-hexane-2 : 4-dione *via* the ketonic ester (*cf.* preceding abstracts). Experiments are described showing the action of malonic ester upon the anhydride, with a view to obtain ultimately bi*cyclo*-(0 : 1 : 3)-hexane-4-one.

102. Studies in bridge formation : Attempts to synthesize bicyclic terpenes of the thujane group.

P. C. GUHA *and* N. K. SESHADRIENGAR, Bangalore.

All attempts to prepare solid derivative of the bridged ester (*cf. Proc. Ind. Sc. Congress*, 1935, p. 142) proved futile although the unbridged ester gave solid derivatives with hydrazine hydrate (m.p. 156-57°) with phenylhydrazine (m.p. 150°) with aniline (m.p. 262°) and with alcoholic ammonia (m.p. 225°). Controlled hydrolysis of this bridged ester by dilute acids and water under pressure has been studied and the resulting products are being investigated. Reduction of this bridged 2 : 6-*cyclo*-hexanonedicarboxylic ester with zinc amalgam is in progress.

*cyclo*Hexanone-2 : 6-dicarboxylate on hydrolysis with 10% methyl alcoholic potash gives a compound, m.p. 126°. It is soluble in hot alkali but does not come down on cooling or on acidification. It does not give any colouration with ferric chloride.

103. Attempts to synthesize bicyclic terpenes of the thujane group.

P. C. Guha *and* N. K. Seshadriengar, Bangalore.

Ethyl *cyclo*pentane tetracarboxylate (1 : 1 : 2 : 2) has been prepared in a better yield and on being subjected to alcoholic sodium ethoxide treatment gave a liquid b.p. 105–110°/5 mm., a solid m.p. 162-63° (identified as *cyclo*pentane *trans*-1 : 2-diacid) and another thick viscous undistillable liquid closely resembling the bridged ester described in the preceding paper. These products are being further investigated.

104. *Nor*-caryophyllenic acid.

S. K. Ranganathan *and* N. K. Seshadriengar, Bangalore.

The recent investigations of Ruzicka, Simonsen and others (*Helv., Chim. Acta,* 1935, *18,* 219 ; *J. Chem. Soc.,* 1934, 1806; *ibid.,* 1935, 532 ; *Chem. and Ind.,* 1935, *54,* 151) have shown that *nor*caryophyllenic acid is 1 : 1-dimethyl-*cyclo*butane-2 : 3-dicarboxylic acid. A synthesis of this acid is possible by cyclizing 2 : 2-dimethylbutane-1 : 1 : 4 : 4-tetracarboxylic ester with bromine and subsequent hydrolysis followed by decarboxylation.

Contrary to our expectations, the reaction of *iso*butylene dibromide with malonic ester in alcoholic solution gave ethane tetracarboxylic ester along with some unreacted malonic ester. Heating the magnesium derivative of malonic ester with the halide in alcoholic solution under pressure gave a small amount of a high boiling ester. The rather low yield of this substance, together with the announcement of a successful synthesis of *nor*caryophyllenic acid by Rydon (*Chem. and Ind.,* 1935, *54,* 315 ; *ibid.,* 1395, *54,* 559) has made us suspend this investigation.

105. Action of alkylenedihalides on ethyl *cyclo*pentane-1-one-2 : 5-dicarboxylate.

P. C. Guha *and* N. K. Seshadriengar, Bangalore.

The action of ethylene bromide on the disodium and magnesium derivatives of the keto diester is described. The action of other dihalogen compounds is under investigation.

106. Action of alkylenedihalides on ethyl *cyclo*hexane-1-one-2 : 6-dicarboxylate.

P. C. Guha *and* N. K. Seshadriengar, Bangalore.

Experiments are described showing the action of ethylene bromide upon the disodium and magnesium derivatives of *cyclo*hexanone-2 : 6-dicarboxylic ester. Investigation on the action of other dihalogen compounds, e.g. methylene iodide, trimethylene bromide, *iso*butylene bromide, etc. are in progress.

107. Action of trimethylene bromide on acetonedicarboxylic ester : A new and more convenient method of synthesis of ethyl *cyclo*hexanone-2 : 6-dicarboxylate.

P. C. Guha *and* N. K. Seshadriengar, Bangalore.

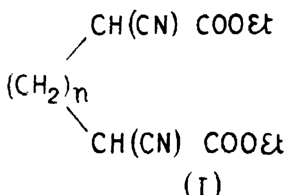
The reaction of sodium or sodium ethoxide with acetonedicarboxylic ester is always attended with the formation of phenolic bodies (Jerdan, *J.*

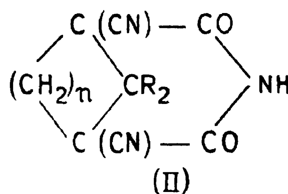
Chem. Soc., 1887, *71*, 1106) and according to Perkin (*J. Chem. Soc.*, 1887, *51*, 739 ; *cf.* 1935 *Sci. Cong. Abstracts* No. 104) of compounds containing oxygen in the ring. Hence, it was considered desirable to try a milder metallic derivative. Trimethylene bromide reacts with the magnesium derivative of acetonedicarboxylic ester to yield the expected ethyl *cyclo*hexanone-2 : 6-dicarboxylate, b.p. 144°/3 mm., phenylhydrazone m.p. 150°. This new method is more convenient to work with and the yield compares favourably with that obtained by the older method (*cf.* 1935 *Sci. Cong. Abstracts* No. 106).

108. On the action of ketones and ammonia on alkylene bis-cyanoacetic esters.

P. C. GUHA *and* S. K. RANGANATHAN, Bangalore.

Guareschi obtained aryl and alkyl substituted dicyanoglutarimides by condensing cyanoacetic ester with ammonia and ketones. The present investigation was undertaken with the object of synthesizing bicyclic compounds of type (II) by the action of ammonia and ketones on alkylene *bis*cyanoacetic esters of type (I).





Methylene biscyanoacetic ester could not be obtained according to the method of Higson and Thorpe (*J. Chem. Soc.*, 1906, *89*, 1458) though repeated under various conditions for more than a dozen times, but the desired ester has been obtained in poor yield by the action of methylene iodide on sodiocyanacetic ester, b.p. 200-5°/25 mm. The above ester (1 mol.) condensed with acetone (1 mol.) in presence of ammonia (3 mols.) to give a yellow crystalline substance, m.p. 256–59°. From a cold alkaline solution of this substance on acidification was obtained a colourless crystalline solid, m.p. 272° (decomp.). Experiments on the preparation of bicyclic compounds of type (II) starting from ethylene *bis*cyanoacetic ester are in progress.

109. Dimethylamino- and diethylamino-phenylimino-camphors—reagents for mercury.

MAHAN SINGH *and* H. B. DUNNICLIFF, Lahore.

The alcoholic solution (1%) of the dimethyl compound gives a deep scarlet colour with mercurous and mercuric salts. The diethyl compound, however, gives a deep violet coloration with mercurous and mercuric salts. The reagents do not give any indication with Pb, Cu, Cd, Co, Ni, $Fe^{\cdot\cdot}$, $Fe^{\cdot\cdot\cdot}$, Ca, Ba, Mn (ous) and Mg salts. Bismuth salts give a faint pink coloration along with a small amount of white precipitate.

The spot reaction can be used to detect 1 part of $HgNO_3$ or $HgCl_2$ in 50,000 parts of water. A drop of Hg-salt gives a rich pink spot which vanishes on exposure to the vapour of ammonia, but a drop of mercurous nitrate gave a fringe round a white spot. On exposure to ammonia, the spot changed to black. These experiments are being continued.

110. Rotary powers of some substituted camphoranilic acids.

MAHAN SINGH *and* H. B. DUNNICLIFF, Lahore.

The paper describes the rotatory powers of 2′- and 4′-ethyl-, 3′- and 4′-nitro-, 3′- and 4′-amino-, 3′- and 4′-fluoro-, 3′- and 4′-aceto-, and 3′- and 4′-acetylamino-camphoranilic acids. The effect of fluorine is in agreement with that of other halogen atoms. The amino- and aceto-groups in the *para* position produce an exaltation in the rotatory power.

111. Condensations of furil and furoin.

A. C. SIRCAR *and* S. C. GUHA, Calcutta.

Benzil and benzoin are very well adapted for various types of condensations (Japp and Hooker, *J. Chem. Soc.*, 1884, T, 672; Japp and Robinson, *ibid.*, 1882, T, 326 Anschutz and Geldermann, *ibid.*, 1891, Abs. 725; Japp and Murray, *ibid.*, 1894, T, 889; Japp and Meldrum, *ibid.*, 1899, T, 1037, etc.). Many of these condensation products are very interesting both from the theoretical as well as practical point of view. It was, therefore, expected that the heterocyclic compounds furil and furoin would also yield a series of similar condensation products. In the present paper a large number of such condensation products have been described.

112. Velocity of transformation of 1 : 3 : 5-triketones into 2 : 6-disubstituted 4-pyrones.

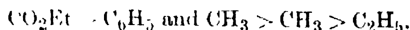
C. W. GUBNIS, W. B BHAGBAT, *and* S. S. DESHAPANDE, Indore.

The transformation of 1 : 3 : 5-triketone such as diacetylacetone into dimethylpyrone with loss of water is supposed to be due to the dehydrating action of the solvent in which the reaction takes place The authors, however, find that no such dehydrating conditions are necessary and that a triketone changes spontaneously into its pyrone in non-dehydrating solvents in the presence of a catalyzer. The velocity of this change is measured and the reaction is found to be strictly unimolecular. Since the total change is the result of these changes, namely (*a*) tautomeric interchange between the keto and dienolic forms of the triketone, and (*b*) conversion of the dienol into pyrone, the equation

$$\frac{1}{t}\log\frac{a}{a-x}=k\frac{m}{1+m}$$

is derived on assumption that change (*a*) is rapid and reversible while (*b*) is slow and non-reversible.

The study of transformation of acetone dioxalic ester, diacetylacetone, dipropionylacetone and benzoylacetyl acetone has shown the effect of the groups carbethoxy, methyl, etc. on the velocity constant of the reaction. The groups arranged in the decreasing order of their effects are



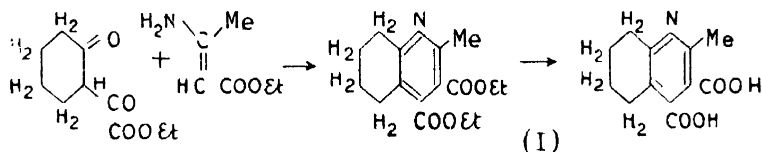
$$CO_2Et > C_6H_5 \text{ and } CH_3 > CH_3 > C_2H_5.$$

113. On the synthesis of Bz-tetrahydro-cinchoninic acid.

UMAPRASANNA BASU, Calcutta.

The present work has been undertaken with the intention of synthesizing a Bz-tetrahydro-cinchoninic acid which would be required for another purpose. Up till now a dicarboxylic acid (I) has been obtained by hydrolyzing with a caustic potash solution (15%), the condensation

product formed by simply mixing ethyl β-aminocrotonate with *cyclo*-hexanone-2-oxalate thus :



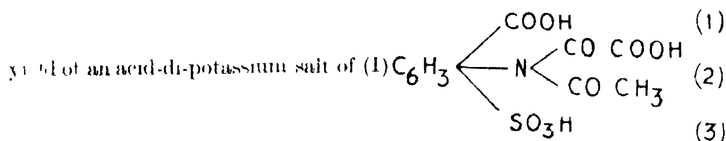
The first condensation product, ethyl 2-methyl-Bz-tetrahydro-quinoline-3 : 4-dicarboxylate, is a refracting yellow liquid, b.p. 191°/5 mm. This on hydrolysis gave the acid (I) as a crystalline solid, m.p. 272-73 with decomposition. Further work is in progress.

114. Oxidation of quinoline-sulphonic acids

K. V. Bokil, Ahmedabad

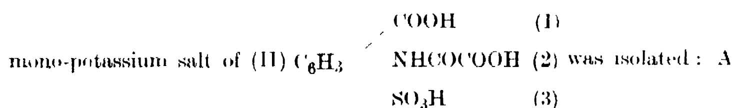
Oxidation of quinoline-8-sulphonic acid with alkaline $KMnO_4$ gives, along with quinolinic acid, only a very small quantity of 2-amino-3-sulphobenzoic acid (Zurcher, *Ber.*, 1888, *21*, 180).

If, however, quinoline-8-sulphonic acid is first reduced, acetylated and then oxidized, the pyridine ring is preferentially broken, and a 65% yield of an acid-di-potassium salt of (I)



is obtained.

Attempts to hydrolyze this with either concentrated aqueous or alcoholic KOH have been so far unsuccessful. When boiled with concentrated HCl (for half an hour), it was partially hydrolyzed, and an acid-mono-potassium salt of (II)



was isolated : A small part is also further hydrolyzed with the formation of free amino-sulpho-benzoic acid, since (1) the aqueous solution gives the characteristic blue fluorescence, and (2) a small quantity of oxalic acid formed, is recovered. If boiling with HCl is continued for a longer period, the substance (II) is completely decomposed.

A similar oxidation of acetyl-tetrahydro-5-quinoline-sulphonic acid is under investigation.

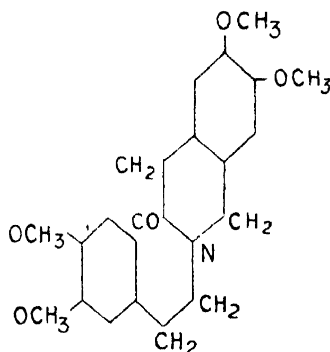
115. On some *iso*quinoline compounds.

P. K. Paul, Calcutta.

With a view to build up some *iso*quinoline skeleton, having in the main that present in emetine, the present piece of preliminary work has been undertaken with the following results.

Homoveratric acid has been condensed with formaldehyde and the resulting lactone (m.p. 100°) has been condensed with β-veratryl

ethylamine, giving rise to a substance (m.p. 123°) of the following constitution.



The suitable condition for its ring closure into the corresponding isoquinoline derivative is being studied.

116. Experiments on the synthesis of alkaloids belonging to chelidonine-chelerythrine group. Part I. Synthesis of α-naphthaphenanthridine, the parent substance of the group.

S. N. Chakravarti *and* M. Swaminathan, Annamalainagar.

A general method has been worked out by one of us (S. N. C.) for synthesizing the alkaloids belonging to chelidonine-chelerythrine group. In a series of preliminary exploratory experiments, we first attempted the synthesis of α naphthaphenanthridine in the following manner.

β-Benzoyl-α-phenylpropionic acid, prepared according to the directions of Lapworth, was first reduced to αγ-diphenylbutyric acid, and the latter cyclized to 1-keto-2-phenyl-1 : 2 : 3 : 4-tetrahydronaphthalene, m.p. 75° by means of concentrated sulphuric acid. The oxime, m.p. 169°, of the ketone was reduced to 1-amino-2-phenyl-1 : 2 : 3 : 4-tetrahydronaphthalene and attempts made to effect the ring closure of the formyl and acetyl derivative of the latter to a compound of the type of α-naphthapharanthridine.

117. Vasicine.

J. N. Ray, Lahore.

A review of the literature of vasicine.

The constitution of dehydroacetyl-vasicine and the oxidation products with hydrogen peroxide are discussed. An alternative synthesis of vasicine is also described.

118. Experiments on the synthesis of yohimbine. Part I. Yobyrine.

J. N. Ray, Lahore.

β-Indyl-ethylamine is converted into tetrahydro-β-carboline. The N O-cyanobenzyl derivative is converted to an aldehyde by Stephen's reaction. Cyclization leads to yobyrine also obtained from yohimbine by selenium dehydrogenation.

119. Studies in the anthraquinone series.

P. C. MITTER *and* MISS TANIMA SEN-GUPTA, Calcutta.

In attempting to prepare anthraquinone-carboxylic acids of the morindone type, we oxidized 1-acetoxy-2-methoxy-6-methyl-anthraquinone with chromic acid and on deacetylating the product, obtained 1-hydroxy-2-methoxy-anthraquinone-6-carboxylic acid, m.p. 195°.

Next, opianic acid was condensed with methyl 5-bromo-salicylate, in presence of sulphuric acid when 5 : 6-dimethoxy-2-(2′-hydroxy-3′-carbomethoxy-6′-bromophenyl) phthalide, m.p. 215°, was obtained. On hydrolysis it gave the corresponding acid, m.p. 253°. Reduction of the phthalide with zinc dust and caustic soda gave 5 : 6-dimethoxy-2-(2′-hydroxy-3′-carboxybenzyl) benzoic acid, m.p. 225°. Neither the acid nor its bromo-derivative could be converted into the corresponding anthrone.

120 Dyes of the triamino-triphenylmethane series.

K. S. VENKAT RAMAN, Benares.

p-Dimethylaminobenzaldehyde has been condensed with two molecules of methyl-aniline, ethyl-aniline, diethyl aniline, methylbenzyl-aniline, benzyl-aniline, *o*-toluidine, *p*-toluidine, etc. in presence of concentrated HCl to yield dyes of the crystal violet type. The leuco bases thus obtained are very easily oxidized, undergoing slow oxidation even on exposure. The leuco bases of the crystal violet series seem to get oxidized much more easily than the members of the malachite green series. The dyes obtained from these compounds range in colour between bluish violet to violet.

121 Dyes derived from acenaphthenequinone. Part V. 2-(6-methyl)-thionaphthene-acenaphthylene-indigos.

S. K. GUHA, Patna

In continuation of parts III and IV in this series (Guha, *J. Indian Chem. Soc.*, 1932, *9*, 423 ; *ibid.*, 1933, *10*, 679), this investigation was undertaken to prepare vat dyes from acenaphthenequinone and its various derivatives and 6-methyl-3-hydroxy-thionaphthene (D.R.P. Nr 204763 ; Friedlander, , 589 ; Auwers and Thies, *Ber.*, 1920, *53*, 2293) with a view to examining the effect, if any, produced on the colour of Ciba scarlet G (Bezdzik and Friedlander, *Monatsh.*, 1908, *29*, 386 ; E.P. 344 08) by the introduction of CH_3-group in the 6 position of the thionaphthene nucleus, and how far this effect can be compared with 2-(5-methyl) thionaphthene-acenaphthylene-indigos (Guha, *loc. cit.*) which were found to be deeper in colour than Ciba scarlet G and its halogen derivatives (Mayer and Schönfelder, *Ber.*, 1922, *55*, 2972 ; Guha, *loc. cit.*)

122. The importance of phytosteryl acetate test for detection of hydrogenated fats in ghee.

K. N. BAGCHI *and* N. S. MAZUMDAR, Patna

The phytosterol acetate test for detecting vegetable fats in ghee becomes unreliable when applied to mixtures of ghee and hydrogenated fats (vegetable ghee), owing to conversion of the phytosterol into resinous hydrocarbons during hydrogenation at high temperatures (250°)

The following observations may, therefore, be helpful to detect hydrogenated fats in ghee by this method : (1) Formation of brown resinous droplets on cooling a hot alcoholic solution of the resaponified sample or its ether extract. (2) Under the microscope the typical cholesterol crystals partially covered with the amorphous deposit are seen but no

129. Essential oil of *Blumea eriantha.*

V. C. AMIN *and* M. S. PATEL, Bombay.

Blumea eriantha is one of the most common weeds in the Bombay Presidency. It has been well-known that this plant yields essential oil possessing camphor-like odour. Blumea plants grown in Bombay were collected and distilled. The plants on distillation yielded oil with the following constants :—

Specific gravity at 31°—0·9290, Acid value—0·86, Saponification value—34·5, Ester value—33·6, Boiling point—224°.

Work on the constitution of the oil is in progress.

Samples of oil have been sent to Germany and the U.K. for evaluation. If the price offered compares favourably with the cost of production, the distillation of *Blumea eriantha* is likely to be a good small scale village industry in some parts of the Bombay Presidency.

130. Essential oil from the rhizomes of *Cyperus rotundus*, Linn.

B. J. HEGDE *and* B. SANJIVA RAO, Bangalore.

The oil has been obtained in an yield of 0·5 per cent., and found to consist mainly of two bicyclic sesquiterpenes, a secondary alcohol $C_{15}H_{26}O$ and a ketone $C_{15}H_{22}O$.

131. Studies in plant colouring matters : Morellin.

B. SANJIVA RAO *and* K. S. SUBRAMANIAN, Bangalore.

A crystalline mono-guanyl hydrazone ($C_{31}H_{37}O_7N_5$; m.p. 206°; (α_D, −748°) of morellin (α_D, −594°) has been prepared, only one of the two keto groups reacting with the reagent. On fusion of morellin with potash, acetic acid, mainly *iso*valeric acid, a dicarboxylic acid ($C_9H_{10}O_4$; m.p. 176°), optically inactive methyl-heptenol, a ditertiary glycol ($C_{16}H_{28}O_2$) having a strong odour of amyl alcohol, and 1 : 3 : 5-xylenol have been obtained. The glycol and the solid acid are being further investigated.

132. A note on the essential oil from the rhizomes of *Rheum emodi*, Wall.

M. GHOUSE MOHIUDDIN, Bangalore.

The volatile oil obtained from the alcoholic extract (yield 0·05 per cent.) has been examined. It is composed of eugenol whose odour is characteristic of the drug and a secondary alcohol which is probably methyl-*n*-heptyl alcohol.

133. Investigations on the acid contents of kokam, *Garcinia indica.*

A. A. KHAN *and* K. C. PANDYA, Agra.

In an investigation on the acid content of *Garcinia gambogia*, known in Malayalam as 'Kadumpuli' and in Bombay as 'Vilayati Imli', it was found that the dried rind of the fruit contained 10% tartaric acid, very much like tamarind itself (*J. Indian Chem. Soc.*, 1931, *8*, 469). *Garcinia indica* is very much used in the west and central India, and preferred to tamarind as an acid element. An analysis of the dried and salted fruit shows that in this case all the acid is malic acid, about 10%, but there is no tartaric acid. The ash contained phosphates, carbonates, potassium, calcium, iron, and possibly sodium.

134. Investigations on āmchur, the peeled dried unripe mango fruit, *Mangifera indica.*

K. C. PANDYA *and* R. K. BOUNTRA, Agra.

The dried unripe mango fruit takes the place of kok ām of the west and tamarind of the south and south-west, in the north, particularly in the United Provinces. It is known as Amchur or merely Khatai. It is found to contain tartaric acid (about 6%), citric acid (about 4%), and oxalic acid (about 1%). The ash shows the presence of phosphate, iron, aluminium, calcium, magnesium, potassium, and sodium.

Investigations of other plant-products used as souring elements of our diet are in progress.

135. Manufacture of tannic acid from myrobolans.

S. R. SUNTHANKAR *and* S. K. K. JATKAR, Bangalore.

By treating myrobolan extract with alumina more of tannins were removed than non-tannins, although the colour of the product was quite satisfactory. Fractional precipitation with increasing quantities of 10 per cent. lead acetate solution and decomposition with sulphuric acid showed that the ratio of tannins to non-tannins is approximately the same in all but the first precipitate. Extraction with a battery of six vats shows that most of the tannins are extracted by water at 70°, about seven times the quantity of myrobolan. Cooling the extract to 10° caused the separation of a good deal of colloidal matter without appreciable loss of tannins. The extract on evaporation and drying in vacuum was found to be equal to commercial tannic acid in dyeing operations.

136. Chemical investigation of an acid isolated from *Ananas sative.*

P. K. BOSE *and* S. BHATTACHARYA, Calcutta.

A crystalline acid has been isolated by Dr. B. C. Guha. It has the composition, $C_8H_{12}O_9$, m.p. 130-132°. It does not reduce Fehling's or ammoniacal silver nitrate solutions. It does not give any colour reaction with alkaline *o*-dinitrobenzene (Bose, *Z. anal. Chem.*, 1932, 87, 110) even after hydrolysis with acids or alkalies. This proves the absence of -CO-CHOH- group in the acid or in the hydrolyzed products. It does not char with conc. H_2SO_4 (hot). It is optically inactive and gave no colour with neutral ferric chloride solution. Potentiometric titration indicated the presence of one $-CO_2H$ group and the equivalent weight was found to be 250. On boiling with dilute alkali (excess) it was apparently converted into a tribasic acid. With diazomethane it gave a crystalline compound, m.p. 73-74°, presumably the methyl ester, which distilled unchanged at 85–90°/0·1 mm. The acid on distillation at 140-45°/0·03 mm. was converted into a neutral body $C_8H_{10}O_8$, m.p. 121-23°, the aqueous solution of which was very stable. The acid is believed to be the anhydride of a saturated tribasic acid or a dilactonic acid.

137. On oroxylin.

P. K. BOSE *and* S. BANNERJEE, Calcutta.

Oroxylin, $C_{19}H_{14}O_6$, m.p. indefinite above 225°, was isolated from *Oroxylum indicum* by Naylor and Dyer (*J. Chem. Soc.*, 1901, 79, 954) in a yield of 0·2%. They obtained phloroglucinol, and benzoic acid, as degradation products. On oxidation phthalic acid was obtained. By a modified method we have obtained 2·8% of crude product from which three crystalline compounds have been isolated, viz. (i) brownish yellow,

m.p. 262–67° (yield 0·5%) which agreed in properties with Naylor and Dyer's oroxylin; (ii) bright yellow, m.p. 235–37° (yield 0·8%); (iii) bright yellow needles, m.p. 212–15° (yield 0·1%). Both (i) and (ii) formed acetyl derivatives which are easily hydrolyzed to the parent compounds. They are not anthraquinone derivatives. (i) gives an orange red precipitate with acidified lead acetate and is unstable towards alkalies. (ii) is stable towards alkalies and does not form any salt with acidified lead solutions. On treatment with diazomethane (i) is converted into a yellow crystalline substance, m.p. 235–37°, not identical with (ii).

138. Chemical examination of the fruits of *Solanum nigrum*. Part I. Its constituents.

G. P. Pendse *and* N. Ghatak, Gwalior.

20 kg. of the fruits of this highly medicinal plant have been extracted with various solvents. The extracts are under systematic examination. A pale yellow, semi-drying oil to the extent of about 10% of the dried seeds of the fruits has been obtained. The juice is under examination for its alkaloidal contents and also estimation of its organic acids. The husk and the seeds after the oil has been extracted off have been exhaustively extracted with alcohol. The alcoholic extracts of both are under further examination.

139. Chemical examination of the fruits of *Solanum nigrum*. Part II. Constitution of the oil.

G. P. Pendse *and* N. Ghatak, Gwalior.

The oil from the fruits of the above plant is under examination. Its physical and chemical constants have been determined and the chemical constitution of the oil is being investigated.

140. Chemical and pharmacological study of *Randia dumetorium* (Sanskrit and Madana: *Deccani-Mendphal*; English: emetic nut).

S. W. Hardikar *and* M. G. Mohiuddin, Hyderabad (Deccan).

The pulp which is reputed to be a good substitute for Ipecacuanha was found to contain an acid-saponin (about 35%), a neutral saponin (about 0·5%), an essential oil about (0·1%), a volatile fatty acid, a brown resin (about 2%), and a green colouring matter.

The acid-saponin is soluble in water, insoluble in absolute alcohol (but soluble in 75% alcohol), ether, chloroform, petroleum ether, and benzene. Its melting point is between 245 and 250°C. It is hydrolyzed by acids, saliva and emulsin, yielding glucose, a pentose, and a sapogenin, melting at 124-25°C.

Further chemical investigation and pharmacological experiments are in progress.

141. Glutamic acid from cashew nut globulin.

M. Damodaran *and* T. G. Sivaswamy, Madras.

A new globulin has been isolated from cashew nut (*Anacardium occidentale*) and analyzed by the method of Nitrogen Distribution described by one of the authors (M. D.). The high dicarboxylic acid content prompted the attempt to prepare glutamic acid from the protein, especially in view of the difficulty experienced in obtaining wheat gluten of good quality locally, which is necessary for the usual method of preparation. It has been possible to isolate from the new protein glutamic acid as the hydrochloride in yields comparable with those from gliadin.

142. Attempts towards synthesis of cantharidin.

B. H. Iyer *and* P. C. Guha, Bangalore.

The disodium derivative of ethyl-3 : 4-diketofuran-2 : 5-dicarboxylate (Johnson and Johns, *Amer. Chem. J.*, 1906, *36*, 290) when reacted with ethylene bromide gave a substance melting at 175°. This is expected to be ethyl 2 : 3-diketo-1 : 4-endo-oxo-*cyclo*hexane-1 : 4-dicarboxylate and has been successfully hydrolyzed to the corresponding diacid, m.p. 320° (decomp.) which has till now resisted all attempts to decarboxylation.

Similar reactions have been studied with trimethylene bromide and also using ethyl thiodiglycollate instead of ethyl diglycollate.

143. The precipitation of cystine by phosphotungstic acid.

M. Damodaran *and* T. G. Sivaswamy, Madras.

The precipitation of cystine by phosphotungstic acid is known to be not quantitative, but in the Van Slyke method of analysis of proteins the cystine value still continues to be widely determined from the content in sulphur of the precipitate obtained when protein hydrolysates are treated with phosphotungstic acid. Serious error is assumed to arise only if the cystine has been subjected to prolonged boiling, and no systematic investigation appears to have been made on the influence of the concentration of cystine on the completeness of the precipitation. In the present study solutions of pure cystine in varying concentrations were subjected to treatment with phosphotungstic acid under conditions identical with those in the Van Slyke method, and the percentage of cystine precipitated at 20° and 30° respectively has been determined. The results show that at 30° proteins containing less than 3% cystine would not produce any precipitate, while in those containing from 5 to 15% cystine, partial precipitation would occur ranging from 50 to 85% of the total cystine present. Similar results were obtained at 20°, except that a rather higher percentage of precipitation occurred. Thus in the most important types of proteins, where the cystine content is below 5%, cystine values obtained by precipitation with phosphotungstic acid are of no significance.

144. Structure of chloroform, fluoroform, bromoform, and iodoform—their analogies with other chloroforms, viz. those of Ge, Sn, etc.

P. B. Sarkar, Calcutta.

Mechanism of several organic reactions where chloroform and alkali take part, e.g. preparation of salicylaldehyde, carbylamine, etc.

145. Nessler's reagents in the estimation of glucose.

M. Goswami, H. Das-Gupta, *and* K. Ray, Calcutta.

Further experiments have been carried on the estimation of glucose in various concentrations. Even a concentration of 0·02% gave very good result. Pathological urine also gave accurate results.

146. The synthesis of ring glycerides.

M. Goswami *and* A. Shaha, Calcutta.

Ring glycerides of the acids maleic, citraconic, phthalic, succinic have been prepared for the first time by using $POCl_3$ as condensing agent.

147. The preparation of organo-mercuric compounds by diazotization.

M. GOSWAMI, B. C. RAY, H. N. DAS-GUPTA, *and* K. MUKERJEE, Calcutta.

This new method for the preparation of organo-mercuric compounds consists in diazotizing amino compounds and adding the diazo solution to a solution of mercuric chloride when the organo-mercuric compound is precipitated.

148. Experiments on the catalytic oxidation of paraffin.

M. GOSWAMI, B. C. RAY, *and* P. DATTA, Calcutta.

It has been already shown that paraffin of m.p. 50° can be oxidized to a higher aldehyde when passed over nickel with oxygen (*J. Indian Chem. Soc.*, 1931, *8*, 533). Experiments are now tried with lower aliphatic hydrocarbon like CH_4, C_2H_4; formaldehyde is found at about 425°. The reaction is facilitated by diluting the hydrocarbon with carbon dioxide.

149. Loss of spirit due to evaporation under Indian conditions.

K. R. GANGULI, Agra.

Experiments were performed with spirits of different strengths ranging from 9·3 to 139·9% proof to study the percentage loss in proof gallonage and the proof strength of the alcohol by keeping them in bottles of the standard quart size prescribed by the United Provinces Excise Department, uncorked but plugged with cotton wool in a way to admit air but to prevent dust to enter. The loss in proof gallonage and proof strength over a period extending about 12 months has been shown. The results represent practically the loss which may be expected in country spirits kept in bottles in more or less open condition in the dry atmosphere.

BIO-CHEMISTRY.

150. The multiplicity of vitamin B_2.

H. G. BISWAS *and* B. C. GUHA, Calcutta.

From parallel experiments on the flavine content and the vitamin B_2-potency of different pulses and also of milk, it has been found that vitamin B_2, as determined biologically, is a complex, of which the flavine (lactoflavine) is an essential component. The existence of other factor or factors (heat-stable) in this complex is indicated.

151. The relation between the composition of the diet and the urinary excretion of ascorbic acid.

A. R. GHOSH *and* B. C. GUHA, Calcutta.

In an investigation carried out in order to throw light on the metabolism of ascorbic acid in relation to dietary metabolism, it has been found that high-fat and high-protein diets lead to an increased excretion of ascorbic acid by the rat.

152. The stability of vitamin C in some food materials.

A. R. GHOSH *and* B. C. GUHA, Calcutta.

The estimation of ascorbic acid in some food-materials, after regular intervals of storage at 0°, shows that in some products the vitamin is particularly unstable, whereas in some it is fairly stable. In *bel* there is, if anything, a slight rise in the apparent ascorbic acid value after 15 days' storage at 0°.

153. Vitamin A assay of ghee.

B. N. BANERJEE *and* S. D. SUNAWALA, Bangalore.

The vitamin A content of Indian ghee has been estimated by the Carr and Price method following the 1932 B.P. The ultraviolet absorption at 328 mμ has also been measured with a Hilger H. 377 Vitameter. This can be done directly on ghee, as also *via* the unsaponifiable matter. Ghee is remarkably free from the interfering agents present in cod liver oils, so that such experiments are easy to perform. Even ten per cent. adulteration of ghee with oil, etc. can be easily and quickly detected in this way.

154. The formation of a reducing substance from mannose by means of tissues *in vitro* and *in vivo.*

B. C. GUHA *and* A. R. GHOSH, Calcutta.

Investigations have been carried out with the different tissues of the rat, rabbit, pigeon, guinea-pig, ox, fish, and snail regarding their capacity to convert sugar *in vitro* into a reducing substance (ascorbic acid ?) reacting with 2 : 6-dichlorophenol-indophenol. *In vivo* experiments on rats and guinea-pigs have also been carried out. The urinary excretion of ascorbic acid (?) by rats after injection with mannose has been found to increase.

155. Colorimetric studies in enzyme action. Part I.

H. B. SREERANGACHAR *and* M. SREENIVASAYA, Bangalore.

The qualitative detection and quantitative study of the course of enzyme hydrolysis can be followed colorimetrically when either the substrate or the products of reaction lend themselves to a colorimetric estimation. In the case of starch, the well-known blue colour, developed by the addition of iodine, can be made use of in following the enzymatic hydrolysis of starch, during which the colour progressively diminishes. A Lovibond Tintometer was used for the purpose of this study. Phosphatases on the other hand liberate the phosphorus from their respective substrates in an inorganic form and in progressively increasing quantities, so that the constituents can be estimated colorimetrically.

156. The action of the ultraviolet light on enzymatic reactions.

SOBHANLAL BANNERJEE *and* H. K. SEN, Calcutta.

In this work the protective action of nitrogenous compounds against the destruction of enzymes by the ultraviolet light has been described. Whilst diastatic activity is completely destroyed in the presence of the ultraviolet light, the addition of phenylaminoacetic acid, gelatine, ammonium citrate, etc., considerably reduces the destructive action. Analogously, if the substrate itself is a nitrogenous body, as for example, caseinogen, the hydrolytic action of pepsin or trypsin is not at all impaired by the action of the ultraviolet light. Pincussen's observations have not been generally confirmed, and the statement by him that the addition of a small amount of fresh enzyme revives the activity, could not be

reproduced in the case of caseinogen investigated by the authors. The optimum pH for the pepsin action on caseinogen has been re-determined and found to be between 2 and 2·2. Analytical methods followed in the present work and in that of Pincussen have been discussed.

157. Method for detecting minute traces of urease and tyrosinase.

K. VENKATA GIRI, Bangalore.

Any substance containing urease sprinkled on the surface of a thin layer of agar gel containing 1% urea causes formation of $(NH_4)_2CO_3$. This diffusing through the gel produces a purple coloured zone on the addition of a drop of phenolphthalein on the surface. In a like manner, tyrosinase can be detected, by the production of a dark colour, when the enzyme material is added on to the surface of a tyrosine containing gel. The time allowed for diffusion is 24 hours.

158. The phosphatase activity of seeds during germination and its synthetic action.

K. VENKATA GIRI, Bangalore.

The phosphatase activity of a number of seeds during steeping and germination has been investigated. Repeated observations have shown that the activity increases four times that of the resting seed in the case of cholam (*Sorghum vulgare*), and about 30 times in the case of ragi (*Eleusine coracana*). This phenomenal increase in activity during germination has been further investigated with a view to throwing light on the mechanism. The probable rôle of activators and inhibitors during germination is being studied. The synthetic action of the enzyme during germination is also investigated.

159. On salivary phosphatase.

K. VENKATA GIRI, Bangalore.

A phosphatase is present in human saliva which hydrolyzes β-sodium glycerophosphate into inorganic phosphorus. The optimum of activity of the phosphatase lies at 4-5 pH. In this respect it differs from other tissue phosphatases. It is suggested that acid phosphatase is typical of body fluids, and the alkaline phosphatase of the organs. The nature and the behaviour of the phosphatase with respect to the action of magnesium and other salts, the purification of the enzyme and the action of inhibitors are being studied.

160. On liver amylase.

K. VENKATA GIRI, Bangalore.

Glycerol extract of acetone dried rat liver powder contains an amylase with a low maltose forming level, whereas the aqueous extract of the powder contains an amylase which has a high maltose forming function at the blue-violet iodine colour stage. Thus a complex system containing more than one amylase with varying degrees of maltose formation is present in liver. Further work is in progress to show whether the low maltose forming function of the enzyme present in glycerol extract is due to the presence of a specific inhibitor for the maltose forming enzyme, or whether it is a function of the enzyme molecule itself.

It has been further observed that of all the livers examined (sheep, swine, and rat), the liver of the rat contained a very active amylase.

161. The effect of metal compounds on tissue phosphatase. I. The influence of lead salt.

K. VENKATA GIRI *and* N. C. DATTA, Bangalore.

Investigations have been undertaken to study the effect of lead salt on the phosphatase activity of different tissues. The results so far obtained indicate that kidney phosphatase purified by the method of Albers (*Z. physiol. Chem.*, 1935, *232*, 189) is inhibited by lead salts in concentrations at which lead is considered to be toxic. The study is extended to the phosphatase of blood, bone, liver, and intestines. With a view to correlating the behaviour of lead salt in *vitro* and in *vivo*, experiments are being conducted with rabbits by injecting lead salts and determining the phosphatase changes in various tissues of the animals.

162. A new bacterium from rotten potatoes.

H. K. SEN *and* G. C. DAS GUPTA, Calcutta.

A new type of facultative anærobic organism has been isolated from rotten potatoes. The optimum temperature and pH for the reaction are 42–45°, and 8–8·5 respectively. It can ferment starch and all pentose and hexose sugars. The products obtained by fermentation can be grouped under two heads: (i) Liquid products consisting of alcohol, formic and lactic acids and traces of acetone. (ii) Gaseous products consisting mainly of CO_2 and H_2, with 3-4% of CH_4 only. The organism belongs to the same genus as the bacilli actoethylicum and Macerans, but is definitely of a different species. The main differences in its cultural characteristics from the other two are the following: (*a*) It is non-motile, whereas the other two are motile. (*b*) It ferments galactose and lævulose both under ærobic and anærobic conditions, with either peptone or ammonium salts as the source of nitrogen. But bacillus acetoethylicum ferments these two sugars under anærobic condition only, with ammonium salts as the source of nitrogen. Bacillus Macerans cannot at all ferment galactose and lævulose. (*c*) The most characteristic phenomenon in this case is that about 70% of the sugars are converted into lactic acid with a small quantity of succinic acid. No non-volatile acid is produced in the other two cases. Instead of acetic acid, formic acid is the only volatile organic acid produced, whilst alcohol as high as 25% of the quantity of sugar taken for fermentation has been recorded. These organisms have vegetative cells ($2–4\mu \times 1\mu$) having spores ($2\mu \times 1\mu$).

163. The fixation of atmospheric nitrogen in the soil and the utilization of molasses.

N. R. DHAR *and* S. K. MUKHERJI, Allahabad.

When sterile cane sugar solution and sterilized soil are exposed to sunlight in quartz vessels under sterilized conditions, the ammoniacal and total nitrogen are increased.

When air freed from bacteria and oxides of nitrogen and ammonia is passed through a solution of glucose or cane sugar mixed with freshly precipitated ferrous hydroxide, appreciable amounts of ammonia are formed.

It appears, therefore, that nitrogen fixation can take place in the complete absence of bacteria provided energy is available from the photochemical or induced oxidation of sugars.

When molasses are mixed with unsterilized soil and exposed to sunlight, the ammonia content goes on increasing with the exposure up to a limiting value.

Molasses when added to soil in the field also increase the ammoniacal and total nitrogen contents of the soil.

Molasses have been used as manure in increasing the yield of sugarcane to the extent of 36%. Rice cultivation is also improved by the addition of molasses to the soil.

164. Denitrification in sunlight and its retardation.

N. R. DHAR *and* S. K. MUKHERJI, Allahabad.

The velocity of the thermal and photochemical decomposition of an aqueous solution of NH_4NO_2 has been determined at 40° and 50°. The velocity of the thermal decomposition is increased by an increase of temperature, but the photochemical velocity is slightly affected by an increase of temperature. The ratio of photochemical to the thermal decomposition of NH_4NO_2 is higher at 40° than at 50°; i.e. when the temperature is high, the thermal decomposition of NH_4NO_2 is marked.

Copious decomposition of mixtures of $(NH_4)_2SO_4$ and KNO_2 in the presence of dry soil and exposed to sunlight in the months of April, May, and June has been observed.

A solution of α-alanine and KNO_2 mixed with soil and exposed to sunlight undergoes considerable loss of nitrogen.

Sterile solutions of $(NH_4)_2SO_4$ and KNO_2 mixed with sterilized soil when exposed to sunlight in quartz boiling tubes show considerable decomposition with evolution of gaseous nitrogen.

Organic manures, e.g. oil cakes, green manure, farmyard manure, molasses, etc. produce beneficial results, especially in tropical countries, not only by increasing the colloidal content and water retention power of the soil, but also by protecting the soil nitrogen by decreasing the velocity of the formation and decomposition of ammonium nitrite.

INDUSTRIAL CHEMISTRY.

165. A domestic smokeless oven.

H. K. SEN, R. M. PAL, *and* KANAILAL ROY, Calcutta.

A preliminary report of this was published some time ago in the *Proc. Inst. Chemists (India)*. Since then, the question of the storage of the gas produced in the coking of coals used in domestic fire places has been studied, and three types of holders for the gas appear to recommend themselves according to the magnitude of domestic requirement. (i) If the consumption of coal is very moderate, say 10–15 lbs. a day, then the installation of a small gas holder working on the principle of an aspirator, is undoubtedly the most convenient. The holder is made broad and squatty, having an upper chamber to enable it to be filled with water from time to time. The cooking of the evening can be almost entirely effected by this collected gas of the midday cooking. (ii) The second type of gas holder is a divided cylinder or drum of appropriate diameter, the dividing shelf being perforated. This cylinder or drum can be rotated on an axis. The gas from the coking oven enters the top chamber, whilst the water descends through the perforated shelf, and expels any gas that had collected at a previous stage. When the evolved gas nearly expels the total quantity of water from the upper compartment (as can be seen from a level gauge), the operator has simply to rotate the drum by hand through 180°, and the collection of gas continues. In this case the generation and the use of gas are simultaneous. (iii) The direct burning of the gas by a specially adjustable burner is also possible, although storing is more convenient, whether for heating or for small power purposes. For every pound of coal, two cubic feet of gas, about an ounce of tar, and approximately 11·5 ounces of coke are

produced. If the city of Calcutta consumes 4 million tons of coal as domestic fuel, then by creating a collecting organization for the tar, about 50 million gallons of tar could be annually utilized for the fuel, or for the dye industry.

166. The possibility of aluminium production in Bombay.

M. S. PATEL, Bombay.

The discovery of bauxite deposits near Bombay by the author, as anticipated by Dr. C. S. Fox, opens up a new field for the utilization of surplus hydro-electric power at Bombay. The deposit on the Tungar hill near Bombay has been prospected, and nearly 300 samples of bauxite from the deposit have been analyzed. The average composition runs as follows :—

Alumina, 54 to 59% ; Silica, 0·3 to 0·8% ; Iron oxide, 3 to 11% ; Titanium oxide, 2 to 6% ; Compound water, 28 to 31%.

The estimated quantity of bauxite on the plateau works out at one million tons. Alumina has been prepared from an average sample of the bauxite, by the Bayer process on a laboratory scale, with the following composition :—

Alumina, 99·34%, Ignition 0·28%, Soda 0·25%.

Another important raw material for the production of aluminium is petroleum coke for the production of electrodes. Samples of petroleum coke from oil distilleries operating in India have been obtained and examined. The coke produced by the refineries of the Burmah Oil Co., Ltd., which analyzes as : Moisture 0·01%, Volatile matter 9·79%, Sulphur (included in volatile matter) 0·47%, Fixed carbon 90·18%, Ash 0·02%,—has been found to be most suitable for aluminium production.

Probable sites with unlimited water supply and adequate water transport facilities have been surveyed, and waters have been tested as to their suitability for the generation of steam, and for process work in the production of alumina.

The cost of raw materials at possible sites have been worked out per ton of aluminium produced. These compare very favourably with those prevailing at centres of aluminium production abroad. The estimated total cost of production of aluminium ingots works out at Rs. 985 per long ton for a plant producing 3,000 tons of aluminium per annum ; this figure includes the depreciation on the machinery, equipment and buildings, and the cost of labour, supervision, technical control and management. The cost of power is calculated at 2¼ pies per K.W.H. delivered at the works.

167. An investigation on the curing of hides with different mixtures of sodium sulphate and chloride in comparison with khari salt.

B. M. DAS, B. B. DHAVALE, *and* B. N. PAL, Calcutta.

It is a common practice in Bengal to cure hides with khari salt, a saline earth containing various proportions of sodium sulphate and chloride as its two principal preservatives. The curers taking advantage of the presence of the earthy matter often intentionally load the hides with mud and sand and thus the plaster-cured hides of Bengal have been brought into bad repute. With a view to finding out a cleaner and equally effective substitute for khari salt the present investigation was undertaken with different mixtures of anhydrous sodium sulphate and chloride.

The hides treated with different cures were preserved for eighty weeks and observations were made from time to time. It was observed that (1) sodium sulphate or sodium chloride when used alone could not preserve the hides for more than six weeks; (2) the mixtures in which sodium sulphate predominates preserve the hides better than those in which the amount of sodium chloride is greater; (3) the mixture containing 5 parts of anhydrous sodium sulphate and 1 part sodium chloride preserves the hide best and for the longest period; the khari salt sample containing the said proportion of these constituents also yielded a similar result.

168. The extraction of nicotine from Bombay tobaccos and tobacco waste.

V. C. AMIN *and* M. S. PATEL, Bombay.

Nicotine has been extracted by various methods from samples of tobacco grown in various districts of the Bombay Presidency and from tobacco waste. The steam distillation method has been found to be most practical for Indian conditions. A sample of nicotine sulphate of standard concentration has been prepared and tested entomologically, with the result that the product prepared in our laboratory showed almost the same insecticidal value at higher concentrations as the imported material, and about 10% loss at lower concentrations.

Nicotine borate and nicotine arsenate have been prepared and analyzed. Both these are solids and very soluble in water. The borate decomposes and chars on heating without melting, while the arsenate melts at 150°. The insecticidal values of these two compounds are being studied, and are likely to prove very useful solid nicotine insecticides.

The nitrogen content of the tobacco before and after the extraction of nicotine has been determined. The ash of nicotine extracted tobacco has been analyzed with a view to its possible utilization.

169. The continuous hydrogenation of oils.

S. K. KULKARNI JATKAR *and* V. T. ATHAVALE, Bangalore.

Continuing the previous work in our laboratory (J. G. Kane, *Proc. Sci. Congress*, 1935, Calcutta), we are studying the comparative activity of different preparations of nickel catalysts in a continuous process under different pressures. We have found that the wire form of catalyst is most readily prepared in a high state of activity for routine laboratory work.

A plant producing one ton of hydrogenated oil per day is also being fitted up for studying the working of the highly active silica gel catalyst discovered in our laboratory.

170. Base exchange by permutit in molasses.

S. D. AGNIHOTRI *and* S. K. K. JATKAR, Bangalore.

Although the commercial possibilities of the use of permutit in sugar refining are well known, the method of its use in refining cane molasses has not so far been studied in detail. The method of replacing the potassium ions which impart a bitter taste to molasses, by ammonium ions, and the subsequent removal of ammonia by concentration, has been studied by using the conductivity method and checking the results by direct analysis. The product so obtained was inferior to that obtained by removing the salt by electrodialysis. The influence of pH of molasses on the base exchange is being studied.

171. Plastics from corrosive oils.

S. D. AGNIHOTRI *and* S. K. K. JATKAR, Bangalore.

Experiments have been conducted to make bakelite-like products from cashew shell oil and marking nut oil by condensing these with hexamethylenetertramine, tannins, sugars, and molasses. The products with the latter three were always hygroscopic, and with hexa methylene tetramine were very brittle and unsuitable for moulding. Although marking nut oil is the more suitable of the two, it is concluded from numerous experiments that these oils are not suitable for making plastics. The observations are in harmony with the chemical investigations about the nature of the main constituent of these oils as found by Pillay and co-workers (*J. Indian Chem. Soc.*, 1931, *8*, 517; 1935, *12*, 226, 231).

172. A new process for the solvent extraction of castor seed with rectified spirit.

N. G. CHATTERJEE, Cawnpore.

The process is an adaptation of the battery extraction system to suit the requirements of the peculiar properties of castor oil and rectified spirit based on laboratory experiments. The special feature of the process is the method by which the solvent is removed from the extracted oil, and its recovery for reapplication in the process, involving an expenditure of steam which is considerably less than is usually the case in solvent extraction processes. It has been found that by this process 63·5% of oil was obtained out of a total oil content of 64·6% in a sample of decorticated seed, while the maximum loss in solvent would be within 1%.

173. A new method of recovering sugar from *gur* without the production of molasses.

N. G. CHATTERJEE, Cawnpore.

It is well known that one of the main causes of the production of molasses is the use of lime during the process of the preliminary treatment of *gur* solution. In the present method, the albuminous matter, phosphates, and other impurities are removed without the use of lime or any other alkaline hydroxides, while the separation of the sucrose from invertose is carried out by fractional crystallization and precipitation. The process can easily be adopted commercially and may be economically worked on even a small scale.

174. The recovery of potash from ashes.

V. C. AMIN *and* M. S. PATEL, Bombay.

Ashes have been an important source of potash from time immemorial. Even in the present century small scale potash extracting plants came into existence both in Europe and America during the war.

Potash salts have been extracted from two samples of ashes: from ordinary Bombay household ash and from tobacco stalks. A very simple process capable of being operated by an ordinary village worker of common intelligence has been worked out for the recovery of potassium salts and potash at ordinary temperature.

Bombay ash gives K_2CO_3 and KOH with some soda compounds. The ashes from tobacco stalks give on the average 30% soluble salts, which give an actual yield of 59% KCl, 19% K_2CO_3, 2% KOH, 20% K_2SO_4. On further crystallization potassium chloride and potassium sulphate are recovered in almost pure state. It is not possible to effect complete separation of K_2CO_3 and KOH. The mother liquor after the

recovery of K_2SO_4 and KCl contains K_2CO_3 and KOH. Some carbonate separates out on slow evaporation at ordinary temperature, leaving a viscous liquid containing K_2CO_3 and KOH. It is necessary to heat this residue in order to get a dry product. The economics of the process are being worked out.

175. Pastes for storage battery grids.

B. S. SRIKANTAN, Waltair.

The usual recipes given in books and patent literature for the making of pasted electrodes of storage batteries did not give good results. Usually the fillings, apparently good, crumpled to powder when immersed in the electrolyte.

After several trials a composition has been arrived at which is very hard and adherent, and which can be filled in the positive or the negative grid. The negative plate formed by reduction of this for 24 hours at a current density of 1·5 amp. is spongy and yet strongly adherent to the grid. The positive plate is formed in 12 hours at a current density of 1·0 amp., giving a hard buff-coloured peroxide of lead.

176. Photo-voltaic cells containing dye solutions.

B. S. V. RAGHAVA RAO *and* D. S. NARAYANAMURTI, Waltair.

From an intensive study of the cells of the type Pt. (Light) dye solution Pt. (dark) under varying conditions using methylene blue and malachite green, it has been shown that (1) the photo potential varies directly as the square root of the intensity of the exciting light; (2) the maximum potential is developed in regions immediately succeeding the long wave-length limit of the absorption band of the dye.

177. A simple method for estimating carbonates in soils.

S. DAS, Pusa.

1. A simple and rapid method for estimating carbonates in soil has been outlined. It consists in either boiling for 5 minutes or agitating at intervals for half an hour at room temperature a known weight of a soil with a measured quantity of $N/2\text{-}H_2SO_4$ in slight excess of 4 to 5 c.c and 50 c.c. of water in a 500 c.c. conical flask and then titrating back the excess of acid with decinormal caustic soda using phenolphthalein as indicator. The end-point is sharp and titre figures are reproducible.

2. The method has been tested with a variety of soil types available in India and has proved to be of sufficient accuracy to warrant its employment in routine soil analysis, or on the field where a large number of samples have to be quickly tested.

178. The partial coagulation of colloids.

S. GHOSH, Allahabad.

Partial coagulation of negatively charged stannic hydroxide and positively charged ferric and thorium hydroxide sols by monovalent and bivalent coagulating ions has been investigated and the following is the summary of the results:

(1) Sols which are impure and contain large amounts of stabilising electrolytes show more partial coagulation by electrolytes than with pure sols.

(2) Concentrated sols develop more partial coagulation by electrolytes than diluted ones.

(3) Partial coagulation is more prominent in the case of monovalent electrolytes than bivalent ones.

(4) The ratio of the concentration of monovalent coagulating ion just to produce a turbidity of the sols to that of a bivalent ion is smaller than the similar ratio of the concentrations of the two ions to completely coagulate the sols.

It is, therefore, concluded (see Chakravarti, Ghosh and Dhar, *J. Phys. Chem.* 1930, *34*, 326) that the partial coagulation of sols is due to the presence of colloid particles bearing different amounts of electrical charge. An impure sol containing greater amounts of a stabilising electrolyte than a pure sol possesses a large number of colloid particles bearing different amounts of electrical charge.

179. The reduction of freshly prepared molybdic acid solution by glucose in dark and sunlight.

A. K. BHATTACHARYA *and* S. GHOSH, Allahabad.

In previous papers (*J. Ind. Chem. Soc*, *7*, 711, 1930) *Bull. Acad. Sciences U.P.*, Vol. II, *29*, 1932) we have studied the photochemical reduction of molybdic and tungstic acid sols by ethyl alcohol and glucose in presence of sunlight. In this paper molybdic acid is produced by the interaction of ammonium molybdate and hydrochloric acid. Molybdic acid, thus obtained, containing an excess of HCl can be reduced by glucose producing the blue oxide of molybdenum MO_3O_8 both in the dark and sunlight at various temperatures and different acid concentrations and the following is the summary of the results :—

(1) In all cases of reduction both in the dark and sunlight investigated in this paper a period of induction has been observed.

(2) Period of induction increases to a maximum with increasing acid concentration both in the dark and sunlight.

(3) Period of induction quickly decreases with increasing temperature both in the dark and sunlight.

(4) Period of induction is greater in the dark than in sunlight.

(5) The reaction is unimolecular in the dark and becomes zero molecular in sunlight.

(6) Velocity of the reaction in the dark increases with increasing acid concentration and passes through a maximum. This effect is not so remarkable in sunlight.

(7) The temperature coefficient varies between 3 and 4 for 10° rise between 40°C and 60°C in the dark. In sunlight it is very nearly unity.

(8) Temperature coefficient increases with increasing concentration of the acid and decreases with the increasing temperature in the dark.

From our results we conclude that hydrogen ion acts as a catalyst in the reduction of molybdic acid to molybdenum blue by glucose. Hence an acceleration of the rate of reduction is observed in the dark with increasing concentration of the acid but the effect of the acid is not prominent in sunlight. For very high hydrogen ion concentrations the speed of the reaction is again slowed down because large amounts of polymerised molecules of molybdic acid are formed in the presence of acid. In previous papers (*loc. cit.*) we have already emphasised that the period of induction is due to the fact that there are aggregated molecules present in molybdic acid solution which are not active as simple molecules and this view has been further confirmed in this paper.

180. The swelling of gels.

N. A. YAJNIK *and* ASA SINGH, Lahore.

In the present investigation, experiments were carried out to study the swelling of gelatine and glue gels of various concentrations under different conditions. The rate of swelling was found to be rapid at the

beginning but went on decreasing with time and in all cases studied maximum swelling was obtained after a certain interval of time. It was also found that the swelling was greatly influenced by the *p*H of the water used and in case of the gelatine gels maximum swelling was obtained at *p*H 3.0. The glue gels were found to show greater swelling than the gelatine gels under similar conditions and the influence of the addition of various electrolytes of the swelling of gels was found to depend on the nature of the gel and the nature of the electrolyte added.

181. Studies in colloidal behaviour of Indian gums.

N. A. YAJNIK *and* MANPHUL SINGH JAIN, Lahore.

In the present investigation, colloidal behaviour of some of the Indian gums, namely Gond Khair, Kikar, Katira, Isabghol, Mustgi Rumi, Myrrh Mokkah, Ushak and Alkundaru, has been studied by the determination of their physical properties.

All the gums studied were found to possess a negative charge and to show normal behaviour with respect to their viscosity concentration and viscosity temperature relationships. It was rather surprising to note that no direct relationship was found to exist between viscosity and protective power. In majority of cases the surface tension decreased with increasing concentration but in some cases the decrease was negligible at lower concentrations. The relation between the refractive index and temperature was also studied at one concentration only in the case of Gond Khair and Gond Kikar and it was found that there was an abnormal change at 45°C in the case of Gond Kikar.

In general it may be stated that the behaviour of Gond Khair, Kikar, Katira, Isabghol and Myrrh Mokkah (at high concentration) was similar to the behaviour of lyophilic colloids while that of Gond Ushak, Mustgi Rumi and Alkundaru corresponded to that of lyophobic colloids.

Section of Geology and Geography.

President :—DR. B. RAMA RAO, M.A., D.I.C., F.G.S., F.N.I.

Presidential Address.

RECENT STUDIES ON THE ARCHÆAN COMPLEX OF MYSORE.

INTRODUCTION

The Archæan complex on which I intend speaking to-day has already figured in some aspect or other as the main topic of discourse of no fewer than six able addresses from this presidential chair. In 1915, Dr. Smeeth [1] presiding over this section gave a brief sketch of the geology of southern India dealing mainly with the Archæan rocks of Mysore. His conclusions were based on the work of the Mysore Geological Survey carried out mostly under his direction, during the first twenty years of its existence. Since then many of the areas have been re-examined in greater detail, the results of which are found as disconnected notes in the several publications of the State Geological Department. The present termination of the subsequent period of another twenty years forms, therefore, a fitting occasion for a review of these later investigations, and as such I am highly thankful to you for having given me the incentive to collect this scattered information and to place before you a connected account of our recent studies on the Mysore Archæan complex.

In the address referred to, Dr. Smeeth drew attention to the following noticeable characteristics of the Archæans :—

(1) The intrusive relationship of the granites and granitic gneisses towards their associated Dharwar schists.

(2) Absence of the base on which the Dharwars could have been laid down.

(3) Probable igneous origin of almost all the constituent types of Dharwars and the absence of any distinct signs of sedimentation.

(4) Similarity of lithological constitution and stratigraphic position of the Dharwars with the Keewatin schists of the Lake Superior Region.

All these ideas were quite at variance with the orthodox views of the Geological Survey of India. Consequently in two

[1] W. F. Smeeth. Outline of the Geological History of Mysore. Bull. No. 6, *Dept. of Mines and Geology*, Mysore State, 1916.

of the subsequent addresses from this chair they have formed the pivots for considerable criticism. Mr. Middlemiss[1], in 1917, strongly disapproved of almost all these revolutionary statements, but Dr. Fermor[2] (now Sir L. L.) in 1919, accorded a qualified measure of support to the views of the "Mysore Geologists". He admitted the intrusive relationship of the granites towards the Dharwar schists, the auto-clastic origin of many of the Dharwar conglomerates, the igneous origin of hornblende-schists and epidiorites, and the origin of some of the quartzites as the crushed phase of vein quartz, but he did not favour the suggested view of the igneous origin of the majority of the slates, phyllites, mica-schists and quartzites of the Dharwars.

Most of the investigators in the Archæan tracts of Peninsular India, except perhaps Dr. A. M. Heron[3], now agree that the granites are actually intrusive into the schists of Dharwarian aspect. But there is as yet no consensus of opinion regarding the precise mode of origin of many of the types of the crystalline complex of the Dharwars. The theory of igneous origin of the types like quartzites, ferruginous quartzites, conglomerates and limestones advocated by Dr. Smeeth and his followers has been gradually losing ground in Mysore. Some of us who started work unbiassed by earlier views were highly doubtful as to the presumed igneous origin of many of these types. But still definite proofs were lacking and our expressions of mere opinions[4] were of no real scientific value.

Recent investigations, however, have disclosed concrete evidences of sedimentation. Well preserved signs of current bedding, ripple marks, rain prints and sun cracks have of late been discovered in some of the exposures of quartzites of the Shimoga schist belt. A few of the conglomerates of this region contain pebbles of quartzite with recognisable indications of cross-lamination. Some of the mica-schists, phyllites, cordierite-sillimanite-gneisses, kyanite-staurolite-schists and sillimanite-graphite-schists of different areas recently analysed reveal undoubtedly the characteristics of pelitic sediments. These evidences will go a long way to deter our eager tendency to pass such types with a cursory glance, as of unquestionable igneous origin. They throw open the field again for a fresh series of investigations on the structural and stratigraphical disposition

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[1] C. S. Middlemiss. Complexities of Archean Geology in India. *Journ. Asiat. Soc. Bengal*, N.S., Vol. XIII, 1917, pp. cxcv–ccii.

[2] L. L. Fermor. Some Problems of Ore Genesis in the Archeans of India. *Journ. Asiat. Soc. Bengal*, N.S., Vol. XII, 1919, p. clxxv.

[3] A. M. Heron. *Trans. Nat. Inst. Sc. of India*, Vol. 1, No. 2, p. 21, 1935.

[4] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, pp. 98, 102, 106 and 128, 1926. *Op. cit.*, Vol. XXIV, pt. 2, pp. 144–147, 1927.

of the constituents of the Dharwars. They minimise further the obstacles now existing for a comparative study of the "Mysore facies" of the Dharwar schists with others of similar aspect in the disconnected areas of Peninsular India.

Besides, detailed investigations on the series of granulitic hypersthene rocks of Mysore, comparable in character to the charnockites of Southern India, show us that several unrelated series of rock types have assumed some common characters due to various processes of modification. It is not improbable that the charnockites themselves may on careful re-investigation disclose their mode of origin to be different to what is generally ascribed to them.

The classification of the granitic gneisses of Mysore into four different epochs of intrusion has neither been verified nor adopted by other geologists who have mapped the adjacent parts of southern India. My own investigations, however, lead me to believe that our present mode of classification stands in need of considerable revision.

It is only by constant assessing of values of evidence obtained from intensive investigations of different regions, and by a careful co-ordination of results of repeated researches, that something like a general agreement can be reached in solving the profound mysteries of these ancient rocks. Therefore I feel no compunction in choosing once again the problems of Archæan rocks for the topic of my discourse, and I hope you will not regard it an infliction to listen to another address on this well covered ground of Archæan Geology.

THE MYSORE ARCHÆAN COMPLEX.

Out of some 29,000 square miles which form in the main the Archæan complex of the Mysore State, a sixth of the area consists of the Dharwar schists, the rest being covered by vast masses of granites and granitic gneisses of diverse appearances and of different periods of intrusion. The Dharwar schists are found in the State in three well defined bands constituting the Shimoga, Chitaldrug and Kolar belts. They enter the State from the north, and the first two, running in a south-south-easterly trend, gradually straighten up and show an indication of joining up towards their terminations in the southern parts of the State. Apart from them a few other stringers and patches of schists of various dimensions are also found scattered about in the gneissic area.

All the various types of the granites and granitic gneisses of the complex are held to be intrusive into the associated schists, and from amongst these heterogeneous masses, granitic rocks of four different epochs of intrusion have been differentiated.[1]

[1] W. F. Smeeth. *Op. cit.*, 1916, pp. 15–18.

They will be briefly dealt with later, and it would suffice here to note their accepted classification as under :—

4. Closepet Granite. Mainly coarse, pink or grey, slightly foliated, porphyritic granites.
3. Charnockites. A series of granulitic hypersthene-bearing rocks of varying composition ranging from a granite to a hypersthenite.
2. Peninsular Gneiss. A complex of different biotite-granites and a composite series of biotite granitic gneisses with shreds and stringers of crystalline schists.
1. Champion Gneiss. A series of highly crushed, micaceous granitic-gneisses frequently associated with types of minor injections and acidic flows containing blebs of opalescent quartz.

DHARWAR SCHISTS.

Present Classification.

The Dharwar system as developed in Mysore is classified at present into a lower and an upper division, on lithological grounds. In the lower division are included different types of schistose and granular dark hornblendic rocks and amphibolites, associated with thin bands of quartzites, ferruginous quartzites, calciferous granulites[1] and purer patches of crystalline limestones.

The upper division on the other hand consists mostly of greenstones and greenstone schists, schistose felsites, quartz-porphyries, quartzites, limestones and dolomites and banded hæmatite-quartzites. Associated with these there are some larger masses of rocks, diabasic or dioritic in character, which are suggested to be intrusive into this division. They also are hornblendic, but differ from the hornblendic rocks of the lower division in containing a pale green amphibole instead of the blue green species of the latter. Some of them show, though very rarely, relics of the original pyroxene.

The schistose acidic rocks, and their presumed altered phases the sericitic quartzites, the conglomerates, the micaceous gritty schists and the mica-chlorite-schists forming layers or bands in the Dharwars, which had been differentiated and mapped as Champion gneiss prior to 1920, were suggested in that year by the late Prof. Sampat Iyengar[2] to be included among the

[1] Comparable to the calc-granulites of Sir Lewis Fermor, they have been described under a local name "Tarurite" in *Rec. Mysore Geol. Dept.*

[2] P. Sampat Iyengar. The Acid Rocks of Mysore. *Mysore Geol. Dept.* Bull No. 9, 1920, p. 8.

Dharwars, and this suggestion was accepted by Dr. Smeeth[1] in his modification of his original classification of the Archæan rocks.

Some clay-schists, sandstones, quartzites and brecciated manganiferous hæmatite-quartzites were at one time separated in the Chitaldrug district to constitute a third or top-most division (G. R. Formation[2]); but under later adverse criticism they ceased to be classified as a separate unit, the constituent types being regarded as the weathered phases[3] of the Champion gneiss.

This local classification of the Dharwars into the two divisions based on lithological grounds, had not been supported by any recognised structural discordances or proved stratigraphic unconformities. Until a few years back, the dark hornblendic schists, such as those represented in the Kolar Gold Field, had been always regarded as the lowest recognisable members of the Dharwar schists as seen in Mysore. But since 1920 this view has been repeatedly questioned. In some parts of Mysore, similar dark hornblendic rocks have been noticed occurring either as intercalated sheets and sills (Modulgudda region, Hole-Narsipur schist belt[4]), or as intrusive dykes in the chloritic schists. In other places thin runs of dark hornblende-schists are noticed as marginal contact alterations of greenstones and greenstone-schists or of some other member of the chloritic division[5]. Crushed hornblende-syenites, diorites and epidiorites[6] of diverse origins all simulate such hornblendic schists in their outward appearance and even in microscopic sections.

Therefore the present procedure of classifying the Dharwars on the basis of the occurrence of some schisted dark hornblendic rock as an indicator of a definite horizon is, to say the least, unsatisfactory.

Broadly generalised, in the northern districts where the Dharwar schists are well developed chlorite is the conspicuous constituent of the greenstones and greenstone schists, and dark hornblende or hornblendic schists are rather scarce. Associated with them are types which can be regarded normally as limestones, argillites, quartzites and grits.

In the central districts where the Dharwar schists are wedged in, as it were, as narrow bands between the granitic

[1] W. F. Smeeth. Some views about the Archeans of Southern India. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, pp. 50–51, 1926.

[2] P. Sampat Iyengar. *Rec. Mysore Geol. Dept.*, Vol. VI, pp. 82–85.

[3] P. Sampat Iyengar. Acid Rocks of Mysore. *Mysore Geol. Dept. Bull.*, No. 9, p. 3, 1920.

[4] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXI, pt. 2, pp. 177–178, 1924.

[5] B. Rama Rao. *Bull. Mysore Geol. Dept.*, No. XV, p. 21, 1934.

[6] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXI, pt. 2, p. 228, 1924.

masses, dark hornblendes are found very conspicuously in the basic rocks which become sub-schistose to granular. The quartzites and grits are found silicified and recrystallised, and the argillitic types are but poorly represented as remnant stringers and patches of micaceous schists containing various secondary aluminous silicates. The ferruginous quartzites develop different types of bladed or acicular amphiboles.

In the southern districts where there are no wider belts of schists, but thin stringers and bouldery outcrops of various granulites, evidence of fusion and recrystallisation is very conspicuous. The constituent minerals of all the types are clean and fresh, coarsely crystalline and granular in form. Brownish green amphibole, green diopside, hypersthene and garnet are conspicuous among the basic granulites or granulitic schists, and chlorite is scarcely noticeable in any of these rocks. Quartzites are often bouldery and massive and contain garnet, sillimanite and sericite. Kyanite, staurolite, sillimanite, etc. are seen in the micaceous schists which might represent the altered remnants of the pelitic fractions of the schist belt, now torn and scattered in the gneissic complex. Magnetite forms the chief constituent of the ferruginous quartzites with variable proportions of hypersthene, garnet and diopside as accessories.

These conditions indicate a progressive metamorphism from north to south, but sufficient detailed evidence is not yet available to judge whether the rocks of the same formation have been differently affected in different areas by varied conditions or whether the region lays bare from north to south progressively lower and lower sections of separate formations now classified mostly as Dharwars.

The pre-possessed view of the autoclastic nature of all the Dharwar conglomerates, and the presumed igneous origin of the apparent sedimentary types, have acted till recently as insuperable barriers for a closer investigation of the structural and stratigraphical relationship of the various components of these complex formations, and for their correct classification into distinct series on recognisable stratigraphic breaks.

Origin.

Our investigations of the past few years confined to the detection of the sedimentary or igneous origin of the doubtful types, lead us to the following conclusions :—

(*a*) Conglomerates.

The recognition of the basal or sedimentary character of many of the conglomeratic exposures is unfortunately not always easy. Many of the outcrops occupy indefinite horizons amidst the masses of argillitic or chloritic schists

and are not continuously traceable over large areas. The admixture of volcanic material, the crystalline nature of the matrix, and the extreme deformations which the rocks have undergone further complicate matters. Besides, the conglomeratic types formed under different conditions have all been rendered alike in structure by subsequent deformations. Among the types which could be differentiated as of diverse origin the following might be noted :—

(1) Sedimentary deposits forming coarse consolidated products of disintegration from minor igneous injections, mixed with volcanic ashes. Many of the conglomerate exposures of the Shimoga belt belong to this type.

(2) Sheared products of sedimentary quartzites and grits with infillings of vein quartz. (This type is seen at Kattekere in the Hole-Narsipur schist belt.) In this case quartzites and quartz-schist are found as pebbles in a sericitic gritty matrix.

(3) Crushed phases of acidic flows with densely packed coarse (silica filled) amygdales. A few of such exposures are found near Basavapatna in the Sulekere region. Here the crushed amygdales look like quartzite pebbles in a gritty micaceous schist.

(4) Sheared phases of volcanic agglomerates as seen near Tekkalavatti and other places further south in the Chitaldrug belt. These are associated with basic and intermediate effusives, and their crushed phases look like conglomerates with variegated pebbles in a greyish green muddy schist.

(5) Sheared and rounded phases of intrusive breccias. Many different varieties are noticeable amongst this group, including some which have been described as autoclastic conglomerates.

(6) Sheared and rounded phases of the products of differential weathering of some extremely altered igneous rocks.

The correct diagnosis of the original character of any of these numerous types is always beset with great difficulty. A considerable amount of careful and detailed work is still necessary to disentangle the true basal conglomerates from their rival imitators. Recent investigations indicate that some of the conglomerates, at any rate, in parts of the Shimoga and Chitaldrug schist belts are actually of sedimentary origin, and could be classed as of two distinct groups of different ages. The Holalur, Bikonhalli and Channagiri conglomerate series of the Shimoga schist belt associated with bands of quartz-porphyry members have pebbles of only "quartzites" of different coarseness in texture and of slightly differing tints, mixed with pebbles of sheared vein quartz. These form an older series. The other set, forming the Jhandimatti and Kaldurga conglomerates of the Shimoga belt and the Aimangala conglomerate of the Chitaldrug belt, contain in addition to pebbles of "quartzites", pebbles

of "granites", "ferruginous quartzites", small patches of chloritic schists, coarse grains of magnetite, etc., in a micaceous chloritic gritty matrix. Many of the "granitic" pebbles of these conglomerates could be traced to the "granite porphyry" rocks of the schist belts. These conglomerates appear to be of a distinctly later age.

(*b*) Quartzites.

All the well defined outcrops which can be continuously traced over large areas, such as the sericitic and calcareous quartzites and the micaceous and felspathic grits of the northern districts seem to be undoubtedly of clastic origin. They disclose distinct evidences of sedimentation, such as current bedding and ripple marks well preserved in some of their outcrops, as near Nilvagal, Hosur and Saulanga. The secondary crystallisation of their quartz grains and also the occurrence of opalescent quartz in them probably led Mr. Jayaram [1] and other investigators to regard such types as the crushed phases of the Champion gneiss (quartz-porphyry, felsite, etc. which contain the opalescent quartz as a characteristic constituent). The fact that the disintegrated Champion gneiss might have formed the source from which the material for deposition was drawn was evidently overlooked. Anyway, that such has been the actual condition is abundantly proved from the occurrence of grains of this opalescent quartz even in the current bedded and ripple marked portions of the quartzite beds. Among the schists of the central districts, the Modulgudda quartzites of the Hole-Narsipur schist belt indicate, again, signs of current bedding, ripple marks and rain prints, though not so clearly as in the former area. In the southern districts where the stringers of schists are more intensely metamorphosed, and also in the quartzite bands amidst the hornblendic schists, similar indications have not been noticed so far. Probably a more careful and detailed examination in the future may reveal some of these characters.

The crushed phases of quartz reefs, which in many instances look like the typical quartzites, are rarely conformable in their strike with the associated schists. Besides they are not traceable continuously over long distances.

(*c*) Ferruginous quartzites.

A careful study of the ferruginous quartzites disclose again a variety of types. The distinct banded hæmatite-quartzites

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[1] B. Jayaram. *Rec. Dept. of Mines and Geol.*, Mysore State, Vol. XIV, pt. 2, p. 93, 1916.
P. Sampat Iyengar. *Rec. Dept. of Mines and Geol.*, Vol. XIV, pt. 2, p. 131, 1916.

associated with the chloritic schists appear to be the typical member of the Dharwars. Though in outcrops they look like solid beds of banded hæmatite-quartzites, in deep cuttings and sections they are seen to be composed of a number of thin bands of ferruginous rocks, interbedded with layers of argillitic and phyllitic schists, and fine bluish ash-like material.

The types which are in association with the dark hornblendic schists as seen in the central districts often show magnetite or martite in addition and variable proportions of some species of dark coloured acicular amphiboles—actinolite, cummingtonite, bababudanite, etc. The view advocated by Dr. Smeeth and his colleagues that the ferruginous quartzites are formed from the breaking down of the amphibolites [1], the cummingtonite-schists and the bababudanite-schist, is not now in general favour and cannot be upheld. Recent investigations indicate that these amphiboles are secondarily developed in the ferruginous rocks as a result of contact action as seen in the Kudurekanave region [2] in the Huliyurdurga-Kunigal area [3], and even in the Bababudan hills [4]. The intercalation of these banded ferruginous quartzites with other rocks of recognisable or inferable sedimentary source naturally indicates them to be of aqueous origin.

The banding of these rocks is so very fine that in very many cases the individual layers seldom exceed one or two mm. in width. Though the ferruginous and siliceous layers appear to be distinct in hand specimens, their micro-sections show some granular iron ore in the siliceous layers and *vice versa*. In contorted specimens the individual layers are observed to maintain their parallelism throughout their plications without the original siliceous layers ever cutting across the ferruginous bands. This feature, while indicating that the folding or crumpling of the rock has taken place subsequent to its formation, also negatives the idea expressed by the late Prof. Sampat Iyengar [5] and others that such bandings are due to lit-par-lit intrusions of minute veins of quartz.

·What exactly has been the process of this sedimentation is not quite clear. It is probable that these banded ferruginous

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[1] W. F. Smeeth. Inspection Notes. *Rec. Mysore Geol. Dept.*, Vol. IX, p. 87.

[2] B. Rama Rao. *Bull. Mysore Geol. Dept.*, No. XV. 1934.

[3] B. Jayaram. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, p. 63, 1926.

B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXIII, p. 100, 1926.

[4] B. Jayaram. *Rec. Mysore Geol. Dept.*, Vol. XX, pt. 2, p. 42, 1923.

C. S. Pitchamuthu and M. R. Srinivasa Rao. *Current Science*, 1, pp. 276-77, 1933.

[5] P. Sampat Iyengar. *Rec. Mysore Geol. Dept.*, Vol. X, pt. 2, p. 53.

quartzites, like their compeers of the Lake Superior region, have been formed by chemical precipitation, the alternations of fine layers being brought about by some process comparable to the Liesegang phenomenon as has been suggested by others.

Some of the banded jaspery ferruginous schists of the Ingaladhal area (Chitaldrug schists), which form a sort of gossan to the cupriferous lodes, are seen to grade downwards into a compact dark grey pyritiferous cherty rock (silicified felsite ?). The fresh specimens of the latter in microsections show a micro or crypto-crystalline ground of silica with a few parallel minute fissures or veinlets filled with ferruginous oxides and carbonates giving rise to an incipient banded structure. A careful comparative study of this type with the typical banded hæmatite-quartzites might throw some light on the precise mode of their formation.

There are indications that a part at least of these original banded ferruginous quartzites has been broken down and re-deposited as normal clastic sediments in the form of friable impure ferruginous silts and quartzites. This is clearly seen among the well defined ferruginous quartzite beds of the Mallebennur-Sulekere region, which show in their upper layers rain prints and well preserved suncracks.

The banded ferruginous quartzites have undergone many changes subsequent to their formation. In some of the outcrops of the Chitaldrug district, by surface weathering and reconstruction they have given rise to a brecciated type, in which patches of the banded hæmatite-quartzite occur in a jaspery ferruginous cement.

The ferruginous quartzites have developed at their contact with acid and basic intrusives various acicular amphiboles as already noted. The cummingtonite-bearing types give rise further to ortho and clino-pyroxenes at their contact with the later intrusive Closepet granites. Some of these hypersthene bearing ferruginous rocks seem to me to be the types which have been described by Mr. Jayaram [1] and the late Mr. Slater [2] as of the Charnockite series.

A few other types of the ferruginous schists, which during the earlier days were mapped as ferruginous quartzites, have no relations with the typical banded ferruginous quartzites. Crushed quartz reefs of the gneissic complex, near the ferruginous formations impregnated with ferruginous solutions, have given rise to a type of limonite-hæmatite-quartz-schist, as noticeable in the Kudurekanave region. The weathered products of basic traps circulating along zones of fracture have formed again thin lenticles and bands of jaspery ferruginous rocks. These no doubt could be confused with the typical banded

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[1] B. Jayaram. *Rec. Mysore Geol. Dept.*, Vol. VIII, pp. 106–8.
[2] H. K. Slater. *Rec. Mysore Geol. Dept.*, Vol. VIII, pp. 63–67.

" hæmatite-quartzites ", but they are of minor occurrences, and with sufficient care can be clearly differentiated.

(*d*) Argillitic, phyllitic and micaceous schists.

Associated with the quartzites and some ferruginous quartzites are found some argillitic schists of grey to greyish green colour. They seem to form a composite series, consisting of true argillitic material, ash beds, and highly crushed decomposed fine grained lava flows. In the field, it is almost impossible to detect their true nature and map them separately.

It is thus seen that amongst these various types of recognisable sediments, the quartzites show well pronounced structural indications of shallow water deposition. Their associated argillites and phyllites have no special structures except lamination and signs of bedding, which are but ill preserved. The ferruginous silts also indicate the structural characters of shallow water facies. But the banded ferruginous quartzites show only obscure signs of stratification, and under what conditions they have been formed is not clear.

The disintegrated and transported materials forming the quartzites and conglomerates do not seem to have travelled very far from their original sources.

(*e*) Limestones.

The larger exposures of the crystalline limestones and dolomites in the Shimoga and Chitaldrug schist belts are interbedded with the quartzites, ferruginous quartzites and micaceous grits of recognisable sedimentary origin, and therefore it is probable that they also have originated under similar conditions. The limestones seldom show distinct signs of stratification or bedding, and it is only by virtue of association they have to be presumed to be of aqueous origin. In the central districts, associated with the hornblende-schists, are sometimes found thin bands of limestone which in places show various calc-silicates. They have been stated to be the calcified portions of the contact altered facies of the dark hornblende-schist, and are locally classed as " Tarurites ".[1] The probability of the calc-silicates being the recrystallised products of contact alterations of a sedimentary crystalline limestone has not been adequately tested. In the southern districts the limestone outcrops are still fewer in number, and they show various pyroxenes, corundum, biotites, garnet and other minerals. Scales of graphite are occasionally found in all these types of limestone.

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[1] E. W. Wetherell regarded them as differentiates of a peculiar lava flow. (Vide *Rec. Mysore Geol. Dept.*, Vol. V, pt. 2, p. 4.) Later W. F. Smeeth proved them to be the contact altered phases of hornblende-schists. (See *Bull No. 3, Mysore Geol. Dept.*)

The sedimentary character of these various types can be recognised with careful scrutiny or readily inferred in the exposures of the Shimoga belt where they are least metamorphosed, but in the central and southern districts where they are subjected in addition to dynamic alterations, to contact metamorphism leading to an interchange of material and partial or complete recrystallization, it is often difficult to recognise their original character.

(*f*) Igneous schists.

Many of the schisted types of dark hornblendic rocks, such as those of the Kolar Gold Field, greenstone-schists, some talc-tremolite-schists and talc-chlorite-schists, serpentines and potstones and the schisted phases of felsites, quartz-porphyries and rhyolitic types can be recognised in the field as of igneous origin, and the results of chemical analyses also confirm this field evidence.

(*g*) Doubtful members.

But some garnetiferous biotite-gneisses, biotite-hornblende-schists, garnetiferous hornblende-granulites and some pyroxene-granulites occurring in the gneissic complex in the vicinity of later intrusive Closepet granites fail to afford any reliable clue regarding their original character.

It is thus evident that among the Dharwar schists of Mysore both igneous and sedimentary materials have been mixed up to variable extents.

Distribution.

After this survey of the general characters of the constituent types of the Dharwar schists, I may now proceed to give a brief account of their areal distribution in Mysore, and their probable sequence of succession as disclosed in different areas.

The regional distribution of the Dharwar schists scattered as isolated patches in the State may be grouped as under :—

A	B	C	D	E
Western	*West Central*	*Central*	*East Central*	*Eastern*
Kodashadri belt.	Shimoga belt	Chitaldrug belt.		
Agumbe belt	Bababudan belt.	Chiknaikan-halli belt.	Scattered stringer of schists.	Kolar belt.
Kuduremukh belt.	Hole-Narsipur belt. Attikuppa belt.	Nagamangala belt.		

A. The Western Group.

This is composed mainly of dark hornblendic schists similar to those of the Kolar belt, associated with thin runs of hæmatite-

quartzite. These are exposed forming steep scarps of the Western Ghats of the Mysore frontier amidst dense forests, where detailed mapping is impracticable..

B. The West Central Group.

(1) *Shimoga Belt.* This forms an important section of the Dharwars, covering an area of about 2,500 square miles in the north-west part of the State, and forms the continuation of the schists of the Dharwar district.

The geological interpretation of the region has undergone various modifications since it was originally mapped by the late Mr. Slater in the early years of this present century. Mr. Slater himself had modified his views so often that by his sudden demise in 1913 the work was left in a confused condition necessitating a revision survey. The geologists who subsequently examined this part, with their experience of more intensely metamorphosed regions, fell in line with the views of Dr. Smeeth as to the igneous origin of the crystalline schists. Mr. Jayaram introduced certain modifications and mapped the belt as consisting mostly of various phases of the "Champion gneiss", with thin lenses and bands of basic greenstones.[1] The limestones and ferruginous quartzites were interpreted by him as metasomatic replacements of the Champion gneiss, and the conglomerates and quartzites as the autoclastic and schistose phases of the same. But my investigations in parts of this area have brought to light definite evidences of sedimentation[2] as already mentioned. The first clear proofs of sedimentation occur after the period of intrusion of the quartz-porphyry members. The clastic products of these acidic rocks, combined with the material derived from the weathering of the older greenstones, have formed the source for the oldest recognisable aqueous formations of this region, and the materials which were deposited as quartzites and conglomerates have not apparently been conveyed very far from their sources.

Concurrent with sedimentation, volcanic activity also continued with varied vigour throughout the period, accounting for admixed ashes at different horizons. Subsequent to the formation of the ferruginous quartzites of this period, the region again was intruded by "granite porphyry" rocks which seem to have penetrated only the lower portion of the series. Later denudation of the whole series has furnished material for the deposition of another set of conglomerates, followed by a thin series, ending again with the ferruginous silts and quartzites.

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[1] B. Jayaram. *Rec. Dept. of Mines and Geol.,* Mysore State, Vol. XVI, 1917, pt. 2, pp. 74-75 and map (p. 102).

[2] B. Rama Rao. "Evidences for the sedimentary origin of some of the constituents of the Dharwar Schists", read before this section.

Scarcity of a sufficient number of closely occurring natural sections, combined with the prevalence of thick soil and the heavily wooded nature of the ground, render the tracing of individual beds difficult, and a considerable amount of detailed field work is still necessary to be certain about the exact positions of certain dubious types. The following statement, generalised from a close examination of a few of the typical sections, gives, however, an idea of the probable sequence of rock formations in this part of the Dharwar schists, and the local names suggested for the middle and the upper divisions of this region are tentative and are not found in this sense in any of the publications of the Mysore Geological Department.

Upper Dharwars — Komaranhalli Series

(*e*) Ferruginous quartzites and cherty ferruginous slates with thin intercalations of argillitic layers and probably of ash beds. (Rain prints and sun cracks are seen in some exposures.)

(*d*) Friable ferruginous silts and micaceous ferruginous grits intercalated with thin bands of limestone towards the top. Basic hornblendic sills.

(*c*) Argillitic and calcareous silts, and fine grained quartzites with minute grains of opalescent quartz.

(*b*) Quartzites.

(*a*) Jhandimatti and Kaldurga conglomerates, containing pebbles of mostly granitic rocks.

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Granite porphyry masses of Rangandurga, Balekal and granites of Honnali, Shimoga and adjacent parts.

Middle Dharwars — Hosur Series

(*e*) Banded hæmatite-quartzites (Chandigudda outcrops).

(*d*) Limestones, dolomites and siliceous limestones.

(*c*) Phyllitic and chloritic schists, grey or greenish.

(*b*) Sericite-grits and quartzites with coarse grains of opalescent quartz.

(*a*) Conglomerates (showing pebbles of "quartzites" and quartz-porphyries), felspathic grits and graywackes.

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Lower Dharwars — Igneous Complex

(*c*) Sills of quartz-porphyry, felsite and other types of acid intrusives and their schistose phases.

(*b*) Acid and intermediate flows—rhyolites, keratophyres, etc., with intercalated tuffs and ash beds now seen as dark grey or bluish argillitic layers and beds, altered in places into compact hornstones in contact with (c).

(*a*) Compact greenstone and greenstone-schists, some micaceous or calciferous chloritic schists, etc. (Basic and intermediate lava flows probably with admixed altered ash beds.)

We see here two separate series of ferruginous rocks. In areas far from the recognisable exposures of the granite-porphyry masses, the ferruginous formation of the upper division rests directly on the ferruginous quartzites of the middle division without the intervention of any conglomerate beds, leading to a confusion of the iron-ore rocks of the two distinct series.

(2) *The Bababudan Belt.* This belt of schists lies immediately to the south of the Shimoga belt, and is cut out by the latter by the Shimoga and Tarikere granites. It consists of about 500 square miles, and, as mapped in 1909, was divided into two series, viz., the Bababudan series and the Tarikere series.[1]

The Bababudan series is composed chiefly of hornblendic igneous rocks, thin runs of quartzites and well developed ferruginous banded hæmatite-quartzites associated with solid iron-ores. The previous descriptions indicate that the hornblendic rocks are composed of a number of basic flows, some overlying the ferruginous quartzite.[2] The Tarikere series, on the other hand, is made up largely of chloritic schists (often calcareous), conglomerates and different ultrabasic rocks more or less weathered, and is developed to the north and east of the Bababudan schists.

As usual both the series of rocks are considered to be mainly of igneous origin, and the exact relationship of the two has not been clearly made out, though it is believed that the Tarikere series is younger than and overlies the Bababudan Series.[3] The Tarikere series has been suggested to be the equivalent of the quartz-porphyry series of the Mallebennur-Sulekere region of the Shimoga belt.[4] As I have already pointed out, the quartz-porphyry members of the latter area *underlie* the banded hæmatite-quartzites, and if the Tarikere quartz-porphyries have to be considered as their equivalent, it throws some doubt on the exact position of the Bababudan hæmatite-quartzites—whether they form a different series older than the Tarikere porphyries or are apparently underlying the latter due to local inversions of the folded strata. Precise information is lacking, and for want of personal knowledge I cannot hazard any opinion.

(3) *Hole-Narsipur Belt.* This small but extremely interesting belt of schists, covering about 100 sq. miles, formed part of the area mapped in 1911 by the late Prof. Sampat Iyengar.[5] According to him the region consists mainly of the dark hornblendic schists of the lower division, with some ultrabasic

[1] W. F. Smeeth. Inspection Notes. *Rec. Mysore Geol. Dept.*, Vol. IX, p. 16.

[2] W. F. Smeeth, *ibid.*, p. 18.

[3] W. F. Smeeth, *ibid.*, pp. 23-24.

[4] P. Sampat Iyengar. *Rec. Dept. of Mines and Geology*, Mysore State, Vol. XV, pt. 2, p. 125, 1917.

[5] P. Sampat Iyengar. *Rec. Mysore Geol. Dept.*, Vol. XI, pp. 82–93 and also map 1.

intrusives. The area consists also of thin but well formed outcrops of kyanite-staurolite-schists, which he regarded as the contact alterations of the lower hornblendic series.[1] Re-examining this area in 1921-22, I have given elsewhere a detailed petrographic description of the various rock types which constitute this complex.[2] This belt of schists may be regarded as forming more or less a connecting link between the less altered schists of the northern districts and the more intensely metamorphosed strips and stringers of schists further south in the Mysore district. Last year, once again, I examined portions of this area, and, on the basis of careful field investigations aided by the chemical analyses of selected specimens, I have come to the conclusion that the Modulgudda quartzites, micaceous chloritic schists, kyanite-staurolite-schists, some types of tremolitic schists and the garnetiferous amphibole-schists represent the altered phases of original sediments. The Kattekere conglomerate which could be easily taken for a true conglomerate but for its position, is rather peculiar in its mode of origin. Consisting of a thin series of bedded grits and quartzites intercalated in an argillitic series, it has been subsequently infilled with traversing veins of quartz, some of which are white and others bluish grey. Subjected to severe folding and crushing, the veins of quartz have been split up and rounded to form pebbly lumps in the sericitic gritty matrix.

The sedimentary series have been intruded by thick sheets and sills of basic and ultrabasic igneous rocks, and portions of them by the granitic rocks of the region. Contact alterations, assimilation and interchange of material seem to have given rise to a large number of different types of rocks of petrographic interest, which are under a detailed study at present. Meanwhile, the following tentative classification gives some idea of the main rock formations and the modifications they have undergone.

6. Bettadasatenhalli pegmatitic intrusions, quartz-tourmaline-veins' quartz-veins and Mavinkere granite. (Relative ages doubtful.)

5. Sills and intrusive sheets of "hornblende-diorite"[3] and the amphibole-peridotites[4].

4. Kattekere conglomerate, grits and Modulgudda quartzites, } Sedimentary.

3. Micaceous chloritic schists. }

2. Actinolite-tremolite-talc-schists and serpentine masses. (Origin doubtful.)

1. Greenstones. Very subordinate and not easily recognisable.

By various modifications, these main formations have given rise to numerous types as seen below :—

[1] P. Sampat Iyengar, *ibid.*, Vol. XI, pp. 81–84.

[2] B. Rama Rao, *ibid.*, Vol. XXI, pt. 2, p. 146, 1924.

[3] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXI, pt. 2, pp. 176–178, 1924.

[4] P. Sampat Iyenger. *Rec. Mysore Geol. Dept.*, Vol. XI, pp. 87–91.

A.	Dark hornblendic schists, resulting from (*a*) contact alterations of 1 and 2, with granites. (*b*) The crushing of chilled marginal phases of 5.	
B.	Massive and rudely schisted greyish green hornblendic rock.	From syntexis of 5 and 1 (?).
C.	Pitted talcose soapstone	From syntexis of 5 and 2.
D.	Tremolite-actinolite-schists	Probably alterations from the ultrabasic rocks.
E.	Kyanite-staurolite-schists and their associated garnetiferous amphibole-schist.	Contact alterations of 2 and 3 by later granitic intrusives and also by 5
F.	Tremolite-hypersthene-rock	Contact alterations of 2 with some dolerites.
G.	Biotite-pyroxene-dioritic rocks	Products of dolerite-pegmatite syntexis.
H.	Coarse amphibole-felspar-rock	Product of peridotite-pegmatite syntexis.
I.	Hornblende-biotite-gneiss. (Part of Gunjurbetta granitic gneiss.)	Contaminated portions of granite with the members of groups 3 and 4.

The isolated position of this belt and the extreme alterations of its component types render it difficult to determine the exact position of these rocks in the stratigraphic scale suggested for the various formations of the Shimoga belt. At the eastern margin of this schist belt, there are some banded hæmatite-quartzites which seem to be older than the " hornblende-diorite ". It is probable that only portions of the middle section with remnants of the underlying basic igneous rocks are preserved here.

(4) *Attikuppa Belt.* To the south-east of the Hole-Narsipur belt are two other isolated patches which form the Attikuppa and the Hadnur[1] belts. They consist mainly of some amphibolites and serpentine rocks with fringes of a dark actinolitic schist at their margins. They represent zones 2 and 5 of the Hole-Narsipur belt; but the sedimentary intercalations, noticeable there, are not recognisable in these belts.

C. The Central Group.

The central group of the Dharwar schists forming a continuous belt runs through the middle of the State with a N.N.W. trend in the Chitaldrug district, where it attains a maximum width of 25 miles. Passing southwards through the Tumkur and Mysore districts the belt splits up into narrow branches, and finally disappears a few miles to the south of Seringapatam. It has a total length of about 170 miles in the State, and covers an area of about 2,000 square miles.

The northern portion of this belt, in which some detailed work had been done, was originally classified by the late Prof.

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[1] S. Raghavendra Rao. *Rec. Mysore Geol. Dept.*, Vol. XII, pp. 133–136.

Sampat Iyengar [1] into three formations on the strength of suggested unconformities. But this did not find favour with Dr. Smeeth [2], who interpreted the sequence in quite a different way. A re-examination of portions of this belt of schists shows that though the structure is more complicated in this region, due to the larger number of exposures of basic intrusives, yet a general parallelism between this belt and the Shimoga schists can be found in the sequence of succession of the recognisable sediments. In the central parts, where the basic igneous injections are more numerous, the recognisable clastic rocks become quite subordinate; but on the western side, in the Aimangala-Marikanave region, are seen phyllites, chloritic schists, limestones and ferruginous quartzites similar to those of the Shimoga belt. In this belt there are a number of exposures of dark hornblendic rocks both coarse and fine, apparently similar to those of the Kolar Gold Field. They have not been studied in sufficient detail. One of such is the narrow fringe of dark hornblende-schist which considerably widens out between Sira and Bukkapatna. Originally this was interpreted as of the older formation underlying the chloritic schists, but the structural indications seem to point otherwise. The main rock formations, just like those of the Shimoga belt, can be classified as below :—

Chitaldrug Granite and other later intrusives.

Upper Dharwars.	G.R. Series	Brecciated manganiferous and hæmatite-quartzites. Clay schists and phyllites. G. R. sandstones. Thin pinkish and green shales and chloritic schists. Aimangala conglomerates.	The G.R. formation of Sampat Iyenger with slight modifications.

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Middle Dharwars.	Lakkihalli Series	Jampalnaikankote-Pitlali and Bukkapatna granites. Jogimaradi and Bellara Traps ? Banded ferruginous quartzites. Limestones. Greenish papery - shales, phyllites, and chloritic and micaceous schists, forming a highly crumpled series. Talya conglomerates, grits and quartzites.	Exposed at the sides of the lower division and typically developed in the Talya and Marikanave Aimangala regions.

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[1] P. Sampat Iyengar. *Rec. Mysore Geol. Dept.*, Vol. VI, pp. 67–85.

[2] W. F. Smeeth. Inspection Notes. *Rec. Mysore Geol. Dept.*, Vol. XI, pp. 11–38.

Lower Dharwars.	Igneous complex	Mashed sericitised quartz-porphyry, keratophyre, etc. Deformed acid and intermediate flows with tuffs, ashes, agglomerates, etc. Massive and schistose greenstones with relics of ellipsoidal structures, and some dark hornblendic schists.	Typically developed in the central portion of the belt in the neighbourhood of Chitaldrug.

D. The East Central Group.

In the east-central zone the schists are more or less granular, and occur as thin patches and stringers scattered about in the gneissic complex. In addition to their primary alterations due to dynamic effects, they have undergone later thermal metamorphism at their contact with the Closepet granites. Different grades of metamorphism under varying conditions have developed in them high temperature minerals like diopside, hypersthene, various garnets, sillimanite, cordierite, etc. giving rise to several interesting rock types which have been described of late under various local names, viz., The Bandite series[1], Kodamite series[2], Sakarsanite series[3] and so on.

The thorough re-crystallisation of these rock types has entirely masked their original character, and on account of their occurrence as mere patches or stringers in association with some dark hornblende-granulites or amphibolites, they have been usually regarded as the modified phases of the dark hornblendic-schists of the "lower division". The chemical constitution of some of the types recently analysed shows, however, the recognisable characteristics of pelitic sediments. The rocks indicate a definite stratigraphic sequence in the field and the exposures of the several isolated areas may be correlated as under :—

Bandite series[1].	Kodamite series[2].	Bidloti series[4].	Sakarsanite series[3].
Quartz-magnetite-granulites.	Garnetiferous magnetite-pyroxene-granulites.	Not seen	Cummingtonite-schists, cordierite-sillimanite-schists.
Garnetiferous quartzites.	Garnetiferous quartzites	Sillimanite micaceous quartzites.	Quartz-pyroxene-gneisses, limestones etc.
Cordierite-sillimanite-gneiss.	Cordierite micaceous gneiss.	Cordierite-hypersthene-rock.	
Spheroidal garnetiferous hornblende-granulites.	Spheroidal hornblende-hypersthene-granulites.	Spheroidal hornblende-diopside-granulites.	

[1] B. Jayaram. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, p. 62, 1926
[2] B. Rama Rao, *ibid.*, Vol. XXIV, pt. 2, pp. 134–152, 1927.
[3] B. Jayaram, *ibid.*, Vol. XXII, pt. 2, pp. 29–35, 1925.
[4] B. Rama Rao, *ibid.*, Vol. XXI, pt. 2, pp. 233–239, 1924.

In addition to them, there are numerous other isolated patches, some scarcely exceeding 10 or 15 sq. ft. in dimensions, scattered about in the gneissic complex. Amongst these, the micaceous schists show coarse crystals of andalusite, the siliceous quartz-schists some scales of graphite, and the ferruginous patches coarse crystals of a series of hypersthenes. It is probable that these various types represent the intensely metamorphosed facies of the original sediments (comparable to the middle Dharwars of other areas) preserved as remnant patches in the axial regions of the folded gneissic complex.

E. The Eastern Group.

Kolar Schist Belt :—Situated near the eastern end of the State in the Kolar district, this belt of schists extends north and south for a distance of 40 miles with a maximum width of 4 miles covering in all an area of about 100 square miles. Owing to its importance as the centre of the gold mining industry in the State, the geology of this schist belt has received considerable attention from the officers of the State Geological Department, from the geologists attached to the mining companies and also from other casual observers.

The earliest detailed investigation of the Dharwar schists of Mysore began with this small belt, and the inferences[1] drawn therefrom have influenced to a large extent the interpretation of the geology of the Dharwar schists as a whole.

This belt is composed almost entirely of the dark hornblendic rocks, showing a good deal of variation in texture and structure. These are believed to represent a series of altered basic lavas. Detailed microscopic investigations and the results of analyses of more than a dozen specimens confirm that very many types amongst them are of igneous origin. The disposition of these various types has been plotted in great detail by Mr. Jayaram. A recent petrographic study of Kolar schists by Mr. M. B. Ramachandra Rao, to be published shortly, will form a useful addition to the existing information on these interesting rocks, and it will contain Mr. Jayaram's map slightly modified and reduced to a suitable scale.

Close to the eastern and western edges of this schist belt are some bands of ferruginous quartzite believed to be of igneous origin. My studies of similar rocks in other parts of the State have convinced me of the sedimentary origin of such types, and it remains yet to be seen if these Kolar exposures are in any way different to the others.

I should like to add a few words here regarding the "Sakar-

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[1] W. F. Smeeth. Notes on the geology of the Kolar schists. Appendix to the Report of the Chief Inspector of Mines for the year 1899. *Mysore Geol. Dept.*, pp. i–xiv, 1901.

sanite series " already noted, which have of late given rise to some controversy regarding the interpretation of their origin and correlation. They form a series of cut up and insignificant outcrops of some impure manganiferous limestones, hornblende-schists, quartz-pyroxene-gneisses and cummingtonite-schists, etc., occurring about 2 or 3 miles to the west of the western edge of the schist belt near its southern end. Criticising Mr. Jayaram's suggestion of their probable pre-Dharwarian age, the authors[1] of a recent paper on the origin and correlation of this series have maintained that the several types are the various phases of contact alterations of the dark hornblende-schists of the lower division, and have no existence as a separate series. But Dr. Krishnan[2] relying on their verbal descriptions, suggests the probable alliance of the series with the Gondites (Middle Dharwars) on the strength of the occurrence of some manganiferous marble.

In parts of the Chitaldrug schist belt, especially in the Kudurekanave and Chicknaikanhalli regions, many of the dolomitic marbles of the middle Dharwars of my classification contain variable proportions of manganese, as seen by some of the specimens analysed. Here and there, rhodonite and coloured manganiferous cummingtonites have been produced in such dolomites as results of thermal alterations.

The Sakarsanhalli limestone may perhaps represent a more intensely metamorphosed facies, of a dolomitic limestone of the same horizon. If this were so, by the way the remnants of this series of rocks are consistently dipping towards the main belt of schists of hornblendic rocks, the latter would appear to be of an age younger than the middle Dharwars. Anyway, the Sakarsanhalli exposures are too much cut up and form too insignificant a series to form the basis for any authoritative statement.

Sargur Schists[3]:—Apart from these distinctly recognisable patches of the Dharwar schists, in the south-western part of the Mysore district is a fairly wide area of a highly metamorphosed complex consisting of bands of granulitic schists containing variable proportions of sillimanite, kyanite, staurolite, graphite, corundum, rutile and other minerals usually suggestive of thermal metamorphism of argillaceous sediments. Associated with them are found crystalline limestones having various calc-silicates, quartz-magnetite-pyroxene-granulites, granulitic pyroxenites, peridotites and various amphibolites and eclogitic types. This group of granulitic rocks might be styled the

[1] M. B. Ramachandra Rao and K. Sripada Rao. The Origin and Correlation of the Metamorphic rocks of the Sakarsanahalli area. *Bull. Mysore Geol. Dept.*, No. 14, 1934.

[2] M. S. Krishnan. Presidential address to the Geology Section, *Twenty-second Indian Science Congress*, 1935.

[3] B. Jayaram. *Rec. Mysore Geol. Dept.*, Vol. XIII, pp. 82–90 and pt. 1.

" Sargur series ". The correlation of this complex belt and the original character of many of its constituent types have not been definitely settled. It seems to constitute a jumbled series of intensely altered sediments and igneous rocks. The mineral constitution of some of the types and the association of the hypersthene-granulites (comparable to the Charnockites) suggest the alliance of this series with the Eastern Ghat facies [1] of the Dharwars.

This brief description of the crystalline schists will show you that in the northern districts where the Dharwars are least metamorphosed and well preserved it is possible to classify them into a lower, middle and an upper division. As we proceed southwards, the topmost members disappear, the rocks get more and more metamorphosed, and, owing to the disconnected nature of the exposures, the recognition of specific horizons becomes extremely doubtful. We have to rely on future investigations to decide whether the Sargur region discloses the more intensely metamorphosed facies of the portions of the lower and the middle Dharwars of the Shimoga belt, or reveals a zone of still older rocks not represented in the Shimoga area.

The Base of the Dharwars :—I might say here a word about the base of the Dharwars. It is now well known that the basement rock on which the oldest crystalline schists could have been laid down is not clearly recognisable anywhere in the Archæan tracts of Peninsular India. Similar conditions prevail in the Archæan terranes of the Lake Superior region, South Africa and elsewhere. The perceptible intrusive relationship of the granitic rocks towards their associated crystalline schists, and the apparent absence of the original granitic floor in such Archæan terranes is sought to be explained by the theory of sub-crustal re-fusion. To what extent such re-fusion could have taken place is still a debatable point. In Mysore, evidences of re-fusion and re-crystallization are certainly perceptible, especially in the southern parts of the State, to a limited extent, but the whole mass of the granitic gneisses does not show any striking abnormalities of character suggestive of a re-fusion of mixed material, on a regional scale.

Dr. Smeeth, with his theory of horizontal or lateral invasion of the granitic gneisses, suggests that the older sections of the Dharwars with their original basement rocks might have been lying buried beneath thick sheets of these later invasions [2]. To me it appears that magmatic stoping has played a considerably larger part than is given credence to, and the original base probably remains still as unrecognised islands amidst the later intrusive granitic complex. According to Dr. Smeeth, it is almost impossible to get at the original basement, whereas

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[1] L. L. Fermor. *Proc. Asiat. Soc. Bengal*, N.S. XV, p. clxxvii, 1919.
[2] W. F. Smeeth. *Rec. Mysore Geol. Dept.*, Vol. XI, pp. 62-64.

according to my conception it is possible by careful investigation of the gneissic complex to detect the basement remnants. A very considerable amount of detailed work remains yet to be done on the complex of granitic gneisses before we can profitably speculate as to what might have been the original character of that basement and in what condition it could be recognised now.

GRANITIC GNEISSES.

With this brief notice of the Dharwar schists we may now pass on to the granites and gneisses which occupy by far the greater part of the State. From the gneissic complex of Mysore, granitic types of four distinct epochs of intrusion are claimed to have been separated. My recent investigations indicate that there are only two series of granites of clearly separable periods of intrusion. Granitic types of the groups differentiated as the Champion gneiss and the Peninsular gneiss appear to me to belong to one and the same eruptive epoch.

(1) *Champion Gneiss* :—This term was originally applied to a highly crushed, fine grained, dark grey, micaceous gneiss found intruding the Kolar schists at their eastern edge, and forming with them a crush conglomerate. Some of the specimens of the granitic gneiss show blebs of opalescent quartz of blue, dark grey or smoky brown colour.

The detection of similar opalescent quartz as a constituent of many of the acidic rocks which occur in close association with the basic schists of Dharwars, led to the subsequent extension of the term to include them. Consequently at present the following types of exposures are grouped under this division.

(1) Acidic flows :—Rhyolite, keratophyre and other types described under the name apo-rhyolites.[1]

(2) Minor injections :—Sheets, sills and dykes of quartz-porphyry, felsite and other allied types.

(3) Small stocks, bosses and shield shaped masses[2] of granitic rocks of the schist belts, finer grained and grading into a granite-porphyry at their margins.

(4) Larger granitic massifs, bordering the belts of schists, coarser in texture, often porphyritic and sending apophyses into the schists along their contact.

(5) Various acidic schists, like quartzites, felspathic grits, sericitic grits, etc.

This indiscriminate extension of the term on the basis of the detection of opalescent quartz, however convenient for mapping

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[1] B. Jayaram. *Rec. Dept. of Mines and Geol.*, Mysore State, Vol XIV, pt. 2, p. 90.

[2] B. Jayaram, *ibid.*, Vol. XIV, p. 87.

purposes, has unfortunately led to some confusion and misinterpretation of the mode of origin of the different types and their relative stratigraphic positions.

My recent investigations indicate that the opalescent quartz as an original constituent is found only in the igneous rocks of groups 1 and 2. It occurs as detrital grains in the schists of group 5 which are clearly sedimentary. In the "granite-porphyry" type of group 3, it occurs only as xenocrysts along its margins or else in the xenolithic patches in the main mass. In the granites of group 4, it is very rarely found.

The granite or "granite-porphyry" outcrops of the Shimoga schist belt appear to be the cupolas of the adjacent granite masses, and I agree with Mr. Jayaram in regarding both as the different phases of consolidation of one and the same eruptive magma. Towards their actual contact with the schists, finer grained types and even chilled phases with a felsitic texture are noticeable. But such finer grained phases have to be carefully separated from the distinctly older members of the porphyry series and apo-rhyolites.

This recent recognition of the acidic rocks as of two distinct periods of eruption, viz., (1) Flows and sills of an older period synchronous with the rest of the greenstone schists of the lower Dharwars, and (2) Granite-porphyry and granites of a distinctly later period of intrusion, with an intervening recognisable break, naturally raises the question as to which of these groups the name "Champion gneiss" has to be retained.

The term "Champion gneiss" as originally applied was to the crushed or gneissic phase of a normal granite and as such it is but reasonable to retain that name for the oldest recognisable granitic intrusives (including their finer grained and chilled phases of crystallisation) into the Dharwar schists. There is no need to have any separate name for the acidic flows and sills which form but an integral part of the lower Dharwars.

These oldest granites and granitic gneisses cannot be satisfactorily differentiated from many of the granitic gneisses of the major gneissic complex of Mysore (Peninsular gneiss). Such of the distinguishing characters as are observable between the two have been fully dealt with by me elsewhere.[1]

(2) *Peninsular Gneiss*:—As classified at present the Peninsular gneiss includes the granitic gneisses and gneissic granites of variable appearances, produced by the relative proportion of colourless and coloured minerals and the mode of disposition of the latter. The distinctly plutonic types include granodiorites, granites and adamellites with syenitic and dioritic phases as local modifications. Such diversity of types among the exposures of these complex intrusions can often be traced to the incorporation of disintegrated xenocrysts from stoped out

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[1] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXXIII, pp. 80–101.

blocks of basic schists, to selective fusion, and to varying extents of assimilation of the sunken blocks. In addition, the complex includes various banded granitic gneisses, some with garnets, others with considerable biotite, some highly siliceous and others abnormally sericitic, on which at present we have no reliable information. It is highly doubtful how many of these are actually deformed granites. Combining all the distinctly *intrusive* granitic types bordering the Dharwar schists into one division, the Champion gneiss, it is better to retain the term Peninsular gneiss for the rest of the gneissic complex more as a convenient descriptive term than as an indicator of any distinct granite of an established or definite period of intrusion, leaving open the ground for careful further investigations. It is quite probable that these heterogeneous gneisses might disclose the remnants of the original base on which the Dharwars have been laid down.

(3) *Charnockites* :—In the southern part of the State are exposed a series of hypersthene-granulites of varying composition, which are comparable to the charnockites of southern India, in their general appearance. They are believed to constitute a series younger than the Peninsular gneiss of Mysore. Except in the eastern and western frontiers of the southern parts of the State, where thay are shown as solid belts of mappable dimensions, in the rest of that area the hypersthenic rocks are scattered as isolated bands and stringers often associated with and grading into hornblende-granulites suggested to be of the Dharwar age. My work in the Mysore district has convinced me that it is impossible to separate these basic granulitic rocks as of two unrelated distinct ages,—the hornblende-granulites as of the Dharwar period older than the granitic gneiss (Peninsular gneiss), and the hypersthene-granulites as of a younger formation intrusive into the gneiss.[1]

The solid belt of charnockites of the Biligirirangan range of hills when mapped in detail resolves into a banded series of biotite-gneisses, stringers of bouldery norites and biotite granitic gneisses, containing varying proportions of hypersthene. The area has not as yet been exhaustively studied, but the observable evidences indicate the probability of the hypersthene-bearing gneisses being the hybrid types produced by the incorporation of norite patches in the later formed biotite-granites. The norites and " intermediate charnockites " occur as disconnected patches of boulders amidst the larger masses of granitic gneisses without cutting across their foliation, but rarely it is also seen that some of these isolated patches do transgress the strike of foliation of *some* gneiss which itself occurs as large sized

[1] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, pp. 92–93, 1926.
B. Rama Rao, *ibid.*, Vol. XXIV, pt. 2, pp. 124–126, 1927.

xenoliths in the granitic gneiss of the region. The original nature of the gneissic rock into which the noritic type might have intruded is not in the least clear.

A careful study of the various hypersthene-bearing rocks of the southern parts of Mysore, indicates that the mineral has been produced in different rock types under varied conditions, for instance,

(1) By contact alteration and silicification of the peridotitic masses, as near Dodkanya.

(2) By probable assimilation of argillaceous material by basic intrusives, as near Kodamballi, Kunigal, Sargur and Bidloti. In these instances the hypersthenes are more or less prismatic and show slight differences in tones of their pleochroic colours. They are associated with kyanite, sillimanite and cordierite bearing rocks.

(3) By contact alteration of cummingtonites of the ferruginous formation in the vicinity of the Closepet granites.

(4) By disintegration and incorporation of bouldery norites in some of the granitic gneisses.

(5) By thermal alteration of some varieties of amphiboles at their contact with basic dykes.

All these types are more or less granulitic or sub-schistose, and have a fair resemblance to the charnockites of southern India.

Some years ago the late Mr. Vredenburg[1] made an ingenious suggestion that the charnockites and khondalites may represent the extremely altered phases of Dharwars (volcanics and sediments) and their equivalents, and this was vehemently refuted by the late Prof. Sampat Iyengar.[2] Whether Vredenburg's suggestion could be substantiated or not, the view that the "charnockites" are separated by a time interval of two epochs of granitic intrusion seems to be groundless. A good deal of work has yet to be done on these pyroxene-granulites to understand their definite status. So far as I have seen they do not appear to me to be the differentiated phases of crystallisation of any one original normal igneous rock, as has been claimed to be the case with the South Indian charnockites.

(4) *Closepet Granites:*—The Closepet granites clearly intrude all the formations till now mentioned, and they are in their turn traversed by felsites, porphyries and some dolerite dykes. The granites of this series are usually coarser in texture and often porphyritic, the porphyritic felspars generally being 2 to 3 inches in length. The felspars are mostly some shade of pink, though grey varieties are also noticeable, especially along the

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[1] E. W. Vredenburg. *Journ. Asiat. Soc. Bengal,* N.S., Vol. XIV, No. 8, 1918, pp. 433–448.

[2] P. Sampat Iyengar. *Bull. Mysore Geol. Dept.,* No. 9, pp. 22–24, 1920.

margins of the granites. These rocks have already been sufficiently noticed in some previous addresses[1] from this Chair, and there is no need for me to say anything more about them here.

CORRELATION.

Outside Mysore, excepting a small portion of the Champaner series of Gujerat, I have no personal acquaintance with any of the series of crystalline schists which are being commonly classed with the Dharwars, and as such I do not feel confident to discuss fully the question of correlation of the Mysore facies of Dharwars with their probable equivalents in other parts of Peninsular India. As you are aware, Dr. Krishnan[2] has dealt with this aspect in his presidential address last year, and has given a general scheme of correlation of the Dharwarian rocks of the different regions. He has suggested therein that the Dharwar bands to the north of Mysore are mainly of the iron ore series (upper Dharwars), the older divisions if present being very meagrely represented.

I have indicated in this address that in the less metamorphosed regions of Mysore, it is possible to classify the Dharwars into three divisions, not so much on lithological grounds, but on the strength of clearly recognisable unconformities. What exactly is the magnitude of these stratigraphic breaks, whether they are only local and of minor interest or whether they are traceable consistently over large areas is yet to be ascertained.

In Mysore the "ferruginous quartzites" occur, to variable extents, in all formations,—as thin ferruginised dark grey minutely banded cherty rocks (silicified felsites ?) in the lower division ; as typical banded hæmatite-quartzites in the middle division ; and as reconstructed brecciated types and ferruginous silts in the upper division. Therefore the correlation of the Dharwars as of any particular division on the basis of the occurrence of the "iron ore rocks" without their careful differentiation into one or other of these types is likely to be of doubtful value.

The ferruginous silts of the upper division as seen in parts of the Shimoga and Chitaldrug schist belts appear to be not very extensive within the State, and I do not know if they might have developed to a larger extent further north in the Dharwar district. Similarly, the clearly recognisable ferruginised cherts or felsites in intimate association with the greenstones and greenstone-schists of the lower division are also but poorly represented when compared with the thick series of the banded

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[1] W. F. Smeeth. *Bull. Dept. of Mines and Geology,* Mysore State, No. 6, pp. 18-19, 1916.

P. Sampat Iyengar. *Bull. Mysore Geol. Dept.,* No. 9, pp. 24–26, 1920.

[2] M. S. Krishnan. Presidential address to the Geology Section, *Twenty-second Indian Science Congress,* 1935.

ferruginous quartzite rocks of the middle division. It looks to me as if the iron-ore series of Chota Nagpur and adjacent parts, which Dr. Krishnan classifies as upper Dharwars, corresponds to what I have classified as the middle Dharwars in the Shimoga and Chitaldrug schist belts. It is this division which shows a larger development in Mysore.

As I have already stated, progressive metamorphism is indicated in Mysore from north to south, and on account of the extreme alterations of some of the rock types, and due to their discontinuous distribution, the exact horizons of many of the isolated strips of schists in the southern districts cannot be definitely made out. In these regions it becomes highly doubtful if we are dealing only with the middle and the lower Dharwars or of some series older than the lowest recognised horizons of the northern parts.

If the sillimanite-quartzites and the kyanite, staurolite, sillimanite. graphite-schists with their associated thin bands of crystalline limestones, quartz-magnetite-pyroxene-rocks and various basic granulites, of the "Sargur series" could be satisfactorily traced to be the portions of middle Dharwars more intensely metamorphosed here due to the intrusions of later granites, then the relics of the lower Dharwars will have to be sought for among the intercalations of the basic greenstones in the gneissic complex. It is interesting to note that the mineral constituents of the various members of this "Sargur series" are almost similar to the rock formations of parts of the Sausar series of the Central Provinces and the khondalite series of the eastern ghats, both of which are regarded as of the middle Dharwar division. Two thin lenticles of grey dolomitic marbles are found in the crystalline schists of this series, but no manganiferous horizons are noticeable in the region. Though their lithological characters and association are suggestive of their being of the eastern ghat facies of the middle Dharwar group, definite evidences are lacking to conclude them to be so.

There has been some contention in fitting the Indian Dharwars with the standard scale of classification of the Pre-Cambrian succession of the Lake Superior Region. Sir Thomas Holland [1], while conceding the Dharwars to be Archæan, maintains that they have to be classed only with the Huronians, whereas the Mysore Geological Survey favours the view of the Dharwars being the equivalents of the Keewatin schists.[2]

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[1] Sir T. Holland. *Imperial Gazetteer of India.* Vol. I, ch. II, Geology, p. 55, 1909. Also see Holland's Comments on 'Remarks on the Underground Geology of the Kolar Gold Field'. *Trans. Inst. Min. and Met.* London. Vol. XXXIII, pp. 120–124, 1924.

[2] W. F. Smeeth. *Bull. Dept. of Mines and Geol.*, Mysore State, No. 6, p. 20, 1916.

W. F. Smeeth. *Rec. Mysore Geol. Dept.*, Vol. XXIII, pt. 2, p. 39, 1926.

There has been some disagreement between the Canadian and American geologists regarding the interpretation of the term Archæan. In a paper recently published [1] I have discussed this question of correlation of the Dharwars at some length, and have suggested therein the probability of our Dharwar schists, as classified now, comprising parts of both the Keewatin schists and the Huronians. I have not yet seen any reason to withdraw this suggestion which I have tentatively put forward. To me it appears that the igneous schists (both acid and basic), which I have classified as the lower Dharwars, correspond both in position and character to the Keewatin schists of North America, and it is doubtful if the banded ferruginous quartzites with their associated sediments, correspond to the lower Huronians, or the Grenville series of Canada. If they could be correlated with the former, then the thin series of ferruginous silts and friable quartzites of my upper division of the Dharwars may correspond to some higher horizon in the Huronians. The sequence of succession of the different formations of the Archæan complex of Mysore as given in the tabular statement below is essentially the same as contained in the paper referred to, excepting some minor modifications especially regarding the position of the older series of granitic rocks (Champion gneiss). A considerable amount of detailed mapping has yet to be done in the different Archæan tracts of India before one can, with any confidence, suggest a closer correlation, than that attempted here, of the several components of the Archæans of India, with the well recognised horizons of the Archæans of the Lake Superior region.

Statement showing the tentative classification and correlation of the main divisions of the Archæan Complex of Mysore.

	Mysore.	North American Equivalents.
5.	Closepet Granite (slightly foliated coarse pink and grey granitic rocks—rarely hornblendic).	Algoman granites (slightly foliated pink granites).
	Eruptive contact.	
4.	Crumpled clays, sandstones and the brecciated hæmatite-quartzites, (the G. R. Formation of Sampat Iyengar) and the ferruginous silts and grits and conglomerates of the Komaranhalli area (Upper Dharwars of this paper).	Upper Huronian ?
3.	Granite-porphyry masses and the granites of Shimoga, Honnali etc. (Granitic and syenitic gneisses, foliated grano-diorites, etc.)	Laurentian ? Foliated granitic and syenitic gneisses, etc.

[1] B. Rama Rao. *Rec. Mysore Geol. Dept.*, Vol. XXXIII, pp. 69–79, 1935.

Mysore.	North American Equivalents.
2. (*a*) Older conglomerates, quartzites, argillitic schists, limestones and dolomites and banded hæmatite-quartzites of parts of the Chitaldrug and Shimoga districts, described as Middle Dharwars in this paper. (*b*) Kyanite-staurolite-schists, etc., with their associated pyroxene-granulites of the Sargur series of this paper. Contact alterations of the Middle Dharwars (?)	Lower Huronian ? or Grenville Series of Canada ?
1. (*a*) Schisted greenstones, calc-chlorite-schists, keratophyres, felsites and quartz-porphyry-schists, intercalated with thin bands of mica-chlorite-schists, ferruginous cherts and impure granulitic limestone lenticles. (Described as Lower Dharwars in this paper).	Keewatin effusives, with minor sediments.
(*b*) Some dark granular hornblende-schists, epidiorites, eclogites etc. with subordinate lenticles of amphibole-magnetite-hæmatite-quartzites, and dolomitic limestones of the gneissic complex of southern parts of Mysore. (Contact alterations of the Lower Dharwars ?)	Contact alterations of Keewatins ?
Original Basement ?	Original Basement ?

I am aware that many of my views freely expressed in this address regarding the interpretation of the genesis and classification of these crystalline schists are quite at variance with the expressed ideas of my predecessors in the Mysore Geological Survey. But generalisations based for the time being on the then available data will have to be modified if better and convincing evidences come to light by subsequent detailed investigations. I may say now, that the geology of the Dharwar schists of Mysore, though perhaps more complicated by various igneous intrusions, is not dissimilar in its major aspects from that of the other Dharwarian tracts of Peninsular India. The essential points of differences on the questions of classification and correlation which are still existing may be bridged over by further scrutiny and comparison of results or by a joint investigation of a few selected typical sections of different regions of Archæan tracts by a small committee of experienced geologists in India, who possess an authoritative knowledge of the different regions they represent.

But considerable ground remains yet to be covered on the geochemical side to correctly interpret the involved genetic problems of many of the interesting rock types of the Archæan complex. This needs individual efforts, and I daresay enthusiastic workers will not be wanting to tackle them and give us ere long the results of their investigations, and contribute their share towards enriching the existing information on these interesting rocks.

Section of Geology and Geography.

Abstracts.

GENERAL.

1. The effect of the presence of a dyke in the bed of the Manjra river at Nizamsagar.

G. G. NARKE, Poona.

The damage caused by erosion in front of one of the flood gates at Nizamsagar is described by the author, and suggestions are made for the proper locations of dam sites and flood openings in them.

2. On the saline efflorescence in the Bangalore-Kolar lateritic masses.

M. B. RAMACHANDRA RAO *and* E. R. TIRUMALACHAR, Bangalore.

An interesting phenomenon of saline efflorescence has been noted in the lateritic masses occurring extensively in some parts of the Bangalore and the Kolar districts in the Mysore State. From field observations, it has been possible to trace the various stages in the conversion of the granitic gneiss to laterites. The most well-developed upper zone of these lateritic masses is of a composite character, being constituted of a more or less ferruginous, gritty, mottled clay with abundant indurated, concretionary and nodular laterite. These concretionary nodules are distributed as a network of crude, vertical, or columnar masses in the mottled clayey matrix, and in surface exposures they have a cavernous appearance. Usually, in such caves the saline efflorescence is conspicuous.

The saline earth is mainly composed of a powdery, granular and flocculated mass of clay, some quartz and a limonitic substance. The salinity is due chiefly to NaCl with Na_2SO_4 in some, and they form usually not more than about 0·5 p.c. of the saline earth.

From a detailed enquiry into the various geological and chemical aspects of the efflorescence, the authors conclude that:—

(1) the prevalence of capillary action is definitely indicated in the process of lateritization, and that the segregations of Fe_2O_3 with SiO_2 are probably due to such an action ;

(2) the climatic factor is clearly indicated in the formation of laterites ;

(3) The circulation of the saline solutions (electrolytes) probably separate some silica from these colloidal masses but the absence of this factor on any large scale provides an explanation for the absence of pure bauxites and laterites in this area.

STRUCTURAL GEOLOGY AND STRATIGRAPHY.

3. A note on the stratigraphical distribution of the foraminifera in the Trichinopoly Cretaceous.

L. RAMA RAO, Bangalore.

After giving a brief account of the various foraminifera found in the Trichinopoly Cretaceous rocks, attention is drawn to the gradual change

in the general character of the foraminiferal fauna in passing from the Utatur to the Niniyur stage. The possibility of using this variation for purposes of stratigraphical classification and correlation is discussed.

PALÆONTOLOGY.

4. Fossil echinoids from the Laki dome and the hills near Bagatora, Sind, and their stratigraphical distribution.

RAJ NATH *and* R. C. MISRA, Benares.

While working out the zonal sub-division of the Lower Nari Series, an extensive collection of fossils including nummulites, corals, echinoids, lamellibranchs and gastropods was made in 1932 from areas west of Laki (26° 16′ : 67° 57′) and Bagatora (26° 21′ : 67° 55′).

The echinoids from the collection have been studied and found to support the zoning done in the field. A new species and two new finds for the area have been recorded. The results of the present investigation lend further support to the conclusions derived from a study of the nummulites and the gastropods, which were read before the last Bombay session of the Indian Science Congress.

5. *Fermoria Minima*: A revised classification of the organic remains from the Vindhyans of India.

M. R. SAHNI, Calcutta.

The small discoidal bodies discovered by Mr. H. C. Jones in 1908 from the Vindhyans of India have been the subject of considerable divergence of opinion as regards their systematic position, even extending to whether they belong to the animal or the vegetable kingdom. They have even been regarded as of inorganic origin. Dr. Frederick Chapman has recently attempted to show that they are primitive brachiopods and has proposed a classification creating a number of new species.

At the request of Sir Lewis Fermor, the author undertook the detailed examination of the holotypes and figured and other specimens. He has come to the definite conclusion that these fossils do not show any character which could be definitely attributed to the Brachiopoda. Mr. Chapman appears to have based his species on characters which are not inherent in the fossils but are dependent on their state of preservation. An attempt has been made to show that the species *Fermoria granulosa*, *F. capsella*, and *Protobollela jonesi* are identical with *Fermoria minima*, Chapman. The carbonized nature of the fossils further suggests that they are probably not of animal origin. But much more work remains to be done before the systematic position of these fossils can be satisfactorily ascertained.

MINERALOGY.

6. Notes on agates and amorphous silica in the Deccan traps of parts of Osmanabad district.

C. MAHADEVAN, Lingsugur.

7. The probable occurrence in nature of a mineral containing Al_2O_3, H_2O and K_2O.

M. R. ANANTANARAYANA IYER, Bangalore.

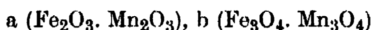
No mineral containing these three constituents alone has, as far as could be seen, been reported before. A mineral of this nature seems to

be present in an earthy looking whitish substance obtained from near Karekurchi mines (Lat. 13° 20′ and Long. 76° 45′). It resembles whitish clay in appearance and physical properties. It has a low refractory quality. It has nearly the ultimate composition of muscovite—the values being 6·76% H_2O, 46·59% SiO_2, 31·77% Al_2O_3, 2·46% Fe_2O_3, 2·73% MgO and 8·13% K_2O. But the combined silica is as low as 4·45%. Strong HCl is not found to dissolve out any appreciable portion of K_2O, Al_2O_3 and to form soluble silica. From these it is inferred that the specimen may contain a mineral containing K_2O, Al_2O_3 and H_2O along with bauxite or a hydrous aluminium silicate or both. Further work is being done to isolate the mineral if possible and study its nature.

8. The formula proposed for Vredenburgite.

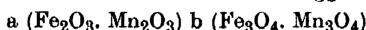
M. R. ANANTANARAYANA IYER, Bangalore.

In a paper read before the Geology section of the Science Congress in 1932,



a $(Fe_2O_3 . Mn_2O_3)$, b $(Fe_3O_4 . Mn_3O_4)$

was suggested by the author as an alternative formula for the mineral, Vredenburgite. His subsequent experimental work on some 4 specimens of the mineral has supported the correctness of this formula as applicable to all specimens. Known weights of the powdered mineral were treated with dilute sulphuric acid and sodium oxalate, reaction was allowed to go on in the cold for different lengths of time so as to get different weights of the unattacked residues and Mn, Fe and MnO_2 values in the residues were determined after filtering them off. The ratio of Mn : Fe in the specimen as a whole was not maintained in the residues in the case of three specimens but was found to be less showing a tendency to approach more and more the value 1. Hence these specimens were chemically non-homogeneous. But the residues of one specimen, where the ratio of Mn to Fe was nearly 1, contained Mn and Fe in the same ratio, thus showing that this specimen was homogeneous chemically. The requirement for the formula suggested is that Mn to Fe ratio should be 1. Hence it is suggested that the formula



a $(Fe_2O_3 . Mn_2O_3)$ b $(Fe_3O_4 . Mn_3O_4)$

may be taken as the correct one for the mineral.

PETROLOGY.

9. The hornblende-pyroxene granulites near the Bull Temple, Bangalore.

B. RAMA RAO *and* M. B. RAMACHANDRA RAO, Bangalore.

A detailed petrographic investigation of the basic inclusions occurring in the gneissic complex close to the Bull Temple, South Bangalore, has revealed the existence of a series of granulitic rocks ranging in character from a norite to an amphibolite. An inquiry into the paragenesis of these varied suite of rocks has indicated the origin of the hornblendic types from the noritic granulites by different degrees of retrograde and contact metamorphism resulting from the intrusion of the granitic gneisses.

The main sequence of formation of the different types has been as follows :—

Types.		Nature of alterations.
(i) Granulitic norites with patches and nodules of finer grained hypersthene granulite.	Origin doubtful	Uralitization.

Types.		Nature of alterations,
(ii) Hornblende, biotite, hypersthene granulites and hornblende biotite granulites.	Low temperature dynamo metamorphosed phases of (i).	Uralitization and amphibolization.
(iii) Hornblende, chlorite, epidote granulites.		Chloritization.
(iv) Banded and veined hornblende, diopside granulites, granular hornblende schists and amphibolites.	Contact modifications of (iii).	Re-crystallization and reconstruction.

The different stages in the retrograde metamorphism are marked by more or less distinctive mineralogical changes, but in the higher grade of metamorphism the textural and structural alterations are also evidenced in addition to the mineralogical transformations. The orthopyroxene (hypersthene) of groups 1 and 2 is a peculiar purplish, highly pleochroic variety and the hornblendes as noticeable in the several groups seem to be of three different types.

10. Petrological notes on marbles from Yellandu.

SYED KAZIM *and* C. MAHADEVAN, Lingsugur.

11. Evidences for the sedimentary origin of some of the constituents of the Dharwar schists.

B. RAMA RAO, Bangalore.

The igneous origin of the types like conglomerates, quartzites, micaceous schists and limestones, forming parts of the Dharwars, postulated by Dr. Smeeth and some of his followers has been unacceptable to many other geologists including the author. Recent detailed investigations in Mysore have shown that despite the fact of the occurrence of a few of such outcrops of presumable igneous origin, many of the larger exposures disclose reliable evidences in support of their sedimentary origin. Structural indications like bedding, current bedding, ripple marks, rain prints, and sun-cracks as noticed by the author, still well preserved, in the less altered members forming parts of the Shimoga and Chitaldrug schist belts are described. The chemical composition of some of the highly crystalline types like cordierite-sillimanite gneisses, sillimanite-graphite schists, etc. which indicate a sedimentary origin are also noted and discussed.

12. Notes on some of the conglomerates of Mysore.

B. RAMA RAO, Bangalore.

Detailed investigation of the 'conglomeratic' band in the vicinity of the Kolar Gold Field, led Dr. Smeeth (1899) to suggest it to be of autoclastic origin composed only of sheared igneous rocks. Since then, several officers of the Mysore Geological Survey have agreed to this view and have held that all the conglomerates which they have examined are only of autoclastic nature. The author had opportunities of re-examining several of these, and finds that though almost all the types show considerable shear and deformation, yet they could be differentiated as of diverse modes of origin, consisting of true sheared sedimentary conglomerates, sheared consolidated products of water-worn pebbles and volcanic ashes, sheared volcanic agglomerates, crushed amygdular flows, etc. which all have the 'conglomeratic' structure. These several types are described in the paper.

13. On the occurrence of Crush Conglomerates of Dharwar age near Luckeeserai, Bihar.

S. C. CHATTERJEE, Calcutta.

The author discusses the possible mode of origin of the Luckeesarai conglomerates recorded by Oldham in his "Manual of the Geology of India."

14. Some basic rocks of Deoghar: a chemical study.

S. K. RAY, Calcutta.

The author records the Chemical analyses of some of the basic rocks of the Santal Parganas, Bihar, which he had described in a previous paper, and discusses their implications regarding the genetic relationship of the rocks.

ECONOMIC GEOLOGY.

15. Possibility of utilization of the nummulitic limestone at Tarakeshwar in the Surat district.

M. S. PATEL, Bombay.

The nummulitic limestone at Tarakeshwar (21° 22′, 73° 7′), Surat district located long ago by Blanford, and the sandstones and the aluminous rocks found near by within a distance of three miles from the limestone deposit are suggested by the author to form suitable raw materials for the manufacture of Portland cement, for the consumption of which Bombay forms one of the most important centres. The author gives in his paper the analyses of the limestones and the aluminous rocks.

16. Magnetic sands at Ratnagiri.

M. S. PATEL, Bombay.

The author records that on the sea shore of Ratnagiri, there is a big shoal covering an area of about a square mile above the high tide level consisting mainly of black magnetic sand. On his examination this was found to contain magnetite and ilmenite with quartz, felspar and amphibole as non-magnetic minerals. The analysis of some of the samples collected by him at random from several places on the shoal showed that they contain about 9 to 11% TiO_2. By magnetic separation, it has been found possible to get concentrates containing 25% and above of TiO_2. As manufacture and consumption of titanium pigments are increasing at a rapid rate, it is suggested that it might be possible to utilize this magnetic sand in future, provided its TiO_2 content is brought up to 48 to 52% by magnetic and other means of separation. Further work on the separation of the magnetic sand with a high intensity separator is noted to be necessary to decide the question of commercial utilization of this magnetic sand.

Section of Botany.

President :—Dr. S. R. Bose, Ph.D., F.R.S.E., F.N.I.

Presidential Address.

BENGAL POLYPORACEÆ.

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Ladies and Gentlemen,

My first duty would be to recall the distinguished Botanists and Mycologists whom the cruel hand of death has snatched away from us since we met in January 1935. May their spirit continue to inspire us !

Hugo de Vries, F. A. F. C. Went, R. Paulson, P. Brühl, B. L. Robinson.

Introduction.

When the Botany section of the Indian Science Congress did me the honour of inviting me to preside at its meeting, I regarded it not so much as a personal honour but as an honour to the group of *Polyporaceæ*, in the study of which I am actively engaged for the last twenty years. It is, therefore, in the fitness of things that I should make a brief survey of the ground that has been covered in the sphere of *Polyporaceæ*, suggesting

incidentally where further work is yet imperative. As Gwynne Vaughan (33) once observed, 'Mycologists, like the fungi themselves, assume a most diversity of forms. Some are systematists, some anatomists, some pathologists who are to do away with plants, some physiologists growing fungi under new and unnatural condition, some cytologists, etc.' Never did I feel more like being a multiple personality than to-day, as I think I do, combining in varying proportions the different rôles, from that of the systematist to that of the cytologist.

Importance of Fungi.

The late Prof. Marshall Ward (64) said, 'If we look at the great groups of plants from a broad point of view, it is remarkable that the Fungi and Phanerogams occupy public attention on quite other grounds (viz. economic) than do the Algæ, Mosses, and Ferns'. But apart from utilitarian considerations, the fungi have an appeal also from the purely academic point of view.

On this point one often hears of the conflict between pure science and applied science, the academic pursuit of apparently useless problems and the practical application of principles for the immediate good of man. On deeper analysis, however, this conflict appears to have little meaning. Pure science and applied science are but fragments of one entity. As Prof. Bower has admirably remarked (12) 'the advance in the prosperity of any country which has progressed beyond the initial stages of settlement follows on the advance of such knowledge as the devotee of pure science not only creates but is also able to inculcate in his pupils. It is then imperative that, in any state which actually progresses, provision shall be made for the pursuit of pure as well as of applied science'. 'Pure Science', said Prof. Lang (43), 'is the root from which applied Science must originate. It is a wise maxim that no scientific man should be guided or restricted in his investigation by any consideration whatever as to the commercial or money-value of his results. Even in continuing to devote ourselves to pure botany we cannot afford to waste time and energy in purposeless work'. Who can forget the familiar words of Lewis Carroll 'No wise fish goes anywhere without a purpose'?

Origin of Fungi.

I need not dilate long on the origin of fungi as an independent group. Gäumann (30) holds that all true fungi are derived from green algæ in monophyletic line. Church was also of the same opinion. Brooks (14) has exhaustively dealt with Church's view that the fungi have been derived from the transmigrant algæ by the loss of chlorophyll. He is decidedly against this view. His outlook upon fungi is that it is an enor-

mous group of organisms of an extreme age and probably of Protist-origin which has developed upon independent lines and shows the same kind of differences between its constituent divisions as do other large phyla of plants and animals. His views as those of a veteran mycologist are certainly entitled to very serious consideration. I entirely agree with him that the fungi which have achieved so much that is unique in the plant kingdom, cannot be looked upon as a race of degenerate organisms devoid of initiation; no group of organisms shows more diversity of species than do the fungi, they even rival the flowering plants themselves in the number of species, have evolved along their own line and have achieved entirely novel types of reproductive mechanism. Dame Helen Gwynne Vaughan (32) also remarked that 'fungi as a whole have their origin, perhaps a common origin, among the Protista and that they form a line of evolution parallel with those of animals and green plants, in some sense comparable to both, but derived from neither. Bacteria, the blue green-algæ and some of the protozoa lack organized nuclei or any form of fertilization, and hence they might be regarded as the remnants of an earlier type of life, preceding the evolution of nucleur structure in fungi, animals, and green plants'.

Previous work on Indian Polyporaceæ.

In May 1922, in the Journal of Indian Botany I contributed a short note on the previous history of the Bengal *Polyporaceæ*. The work on Indian fungi has been so far very scrappy and done at irregular intervals. In 1850, Hooker collected a good number of different groups of fungi in Himalaya, Sikkim, Darjeeling, and Khasya hills; these were all determined by Berkeley and published under the heading of Decades of Fungi in the Kew Gardens Miscellany. Then, in 1874, stray collections of *Polypores* from the Calcutta Botanic Gardens and from Burma were collected by Mr. Kurz and determined by Mr. Currey and published in the Transactions of the Linnean Society—Series Bot., Vol. 1, pp. 121–126. There were some notices of Indian fungi (mostly leaf fungi and *Agaricaceæ* with a few *Polypores*) by Cooke in several scattered volumes of *Grevillea* from 1874 to 1891. In the Kew Bulletin from 1898–1912, George Massee named and published a few *Polypores* with *Agarics* from Bengal, mostly collected and sent by Mr. Burkhill—the then Economic Botanist to the Government of India. Quite recently, stray collections of *Polypores* (mainly from Darjeeling, collected by Mr. H. G. Cave, the late Curator of the Lloyd Botanic Garden) have been determined and published by the late Dr. Lloyd of America in his Mycological Notes. This practically sums up the whole work on Bengal *Polypores*.

GEOGRAPHICAL DISTRIBUTION OF BENGAL POLYPORACEÆ.

In that May issue (of the Journal of Indian Botany, 1922) I published also a note on the geographical distribution of the Bengal species of *Polyporaceæ* along with a short history of them. Subsequently in 1924 (4), I dealt with the problem more fully, grouping Bengal *Polypores* under eight different distributional lists, namely, (I) Bengal species practically cosmopolitan in their range, (II) species with extraordinarily discontinuous distribution, (III) species confined to India and Ceylon, (IV) species found in India alone, (V) species reported from Bengal extending the known range of distribution, (VI) species common to tropical and temperate regions, (VII) species common to eastern and western tropics, (VIII) species confined mostly to eastern tropics. From a consideration of the details of these lists of distribution, it is evident that in our Bengal *Polypores* the Malayan element (the Malaya Archipelago including Java, Sumatra, Sarawak, Borneo, the Philippine Islands, etc. and the neighbouring groups of islands) is predominant and that the Australian element comes next in rank and importance.

The presence of forests, hills, river-beds, etc. changes the character of the flora; therefore I (*loc. cit.*) have considered in detail the climate, the rainfall, the nature of vegetation, and the distribution of *Polypores* in three special localities in Bengal, viz. (1) the hilly district of Darjeeling, (2) Jalpaiguri (Duars Forests), and (3) the forests and river-beds of Sunderbans. The chief difficulty here, as I have remarked in two preceding papers of mine, is that the mycological flora of such a large portion of the world remains unexplored that it is at present impossible to give a general view of the geographical distribution of fungi. Even in some of the *civilized* countries of which the phanerogamic flora has been fully worked out, little has been done towards the collection and publication of lists of fungi. Hence, the most useful thing we can do at present is to compare the collection of one country with that of another and to note the points of difference as well as agreement. Such a comparative study of fungi will certainly enable us to draw more sharply the dividing line between the known and the unknown.

In the case of fungi it often so happens that species which were at one time very common, gradually become somewhat rare until they disappear altogether. The late illustrious Fries (28) said 'The fact must not be lost sight of that some species of fungi which have formerly been common in certain localities may become within our lifetime more and more scarce and even altogether cease to grow there. The cause of this doubtless is the occurrence of some change in the physical constitution of a locality (upsetting the balance of nature), such as that resulting from the destruction of a forest, or from the drainage by ditches and cutting of more or less extensive

swamps, or from the cultivation of the soil'. In this connection J. Reichert (48) is right in holding that in considering the distribution of fungi not merely climatic and edaphic characters but also the previous history of the place have to be considered.

In the case of *Polyporaceæ* it will be seen that geographical limits of species are not so well-marked and definite as in those of Phanerogamous plants. Of course, there are some which are confined to temperate regions, while others are confined to tropical regions alone (eastern and western tropics). But there are still others which are very widely distributed in the temperate and tropical regions as well. When climatic conditions, such as temperature, rainfall, humidity, etc., are analogous, it is astonishing to find the repetition of the species in very distant parts of the globe. But it is usually found that tropical countries, abounding in virgin forests, form the special abode of *Polypores* which grow luxuriantly under the shade of trees affording constant moisture and heat.

Certain *Polypores* are associated with particular species of trees in the wood, either growing on them or close to them on the ground. Whatever influences affect the distribution of these trees affect also the distribution of these *Polypores*. Recently, in 1935 (9), I have recorded the occurrence in the high hills of Lokra (Assam) in Bengal at 8,000 to 10,000 ft. elevation of six European *Polypores* (*P. squamosus*, *P. sulphureus*, *P. gilvus* forma *licnoides*, *Fomes fomentarius*, *F. pinicola*, *Amauroderma rugosus*) which are never found in the plains of Bengal. Therein I have remarked that the phanerogamic flora of our high altitudes is to a great extent European in character and that, as most of the plants of the hills harbouring these species of *Polypores* as parasites or saprophytes do not grow in our plains, we do not come across these fungi in the plains. In the case of some *Agarics* Hatch and Hatch (35) have shown such associations with roots of some of the coniferous and hard wood trees to be mycorrhizal in character.

Conditions for development of Polyporaceæ in Bengal.

Conditions become favourable for the growth of *Polypores* only for a certain part of the year. This growth is greatly influenced by temperature, humidity, and rainfall. A glance at the annual rainfall-report of the different districts of Bengal will show that almost all parts of Bengal have a rainy season of about three or four months from June to September, and in the majority of places the maximum is reached from June to August. There is a great variation in the amount of rainfall; the rainfall is usually periodic as it depends upon the monsoon which blows from south-west across the Indian Ocean from May to the end of September. This is called the summer or wet monsoon and is usually accompanied by heavy rains and thunderstorms. A portion of the south-west current proceeds up the

Bay of Bengal, bringing in the rainy seasons of two or three months in the plains of Bengal. Further north are the Assam hills where the remaining moisture is condensed; thus the rainfall is very great in the province of Assam, often reaching 500 inches in a year. In October a north-west wind called the winter or dry monsoon begins and continues up to April. During this time the rainfall is very small.

Polypores begin to appear in the rainy season from June to July and increase in numbers usually in August, September, and October when the rainy season has almost disappeared but the surrounding conditions are still sufficiently moist. Quantities of them can be easily found in November, December, and January in the case of late rains. Some of them with leathery or corky fruit-bodies and hairy or velvety upper surface persist in the dry season. And it is remarkable that these leathery or corky fruit-bodies of *Lenzites, Polystictus, Daedalea, Trametes,* etc., and densely hairy fruit-bodies of *Polystictus hirsutus, Polys. velutinus, Polys. leoninus, Polys. versicolor, Lenzites betulina,* etc., which are xerophytic and grow on logs and sticks, retain their vitality on desiccation for months or years and, when they are placed under a moist condition, they revive and begin again to liberate spores within a few hours.

Most of the *Polypores* being saprophytic easily grow in places which abound in decaying logs, prostrate trunks, and dead branches, etc. Logs are plentiful in the rainy season, and moreover, low jungles are very common in Bengal. Some of their plants and plant-members usually die in the dry season and supply a host of logs, and hence we find a number of common specimens springing up from different parts of Bengal on such logs. The mycelia of some of the specimens of previous years that are lodged within the tissues of the dead wood, being resistant, easily tide over the dry season, and as soon as the rains appear, some of them at once give rise to fresh hyphæ which work within the tissues of the dead wood and ultimately produce pileus on the outside. This is probably the reason why we suddenly meet with some specimens of *Polypores* in the midst of the driest part of the year, if there be a casual rainfall for a few days only. There are others which do not respond so quickly; for them continued rains have to act on the logs for some time and to make them thoroughly moist; the spores on the surface of the logs or inside the tissues then probably germinate into hyphæ which penetrate inside the wood, and finally towards the end of rains, the mycelium gives rise to sporophores on the outside. That is probably the reason why we meet with the prevalence of *Polypores* just after the rains, or towards the end of the rains, usually from August to October. So, in the former case it is probably a matter of dormant mycelium which gives rise to sporophores in the beginning of rains, and in the latter case probably spores or dormant conidia

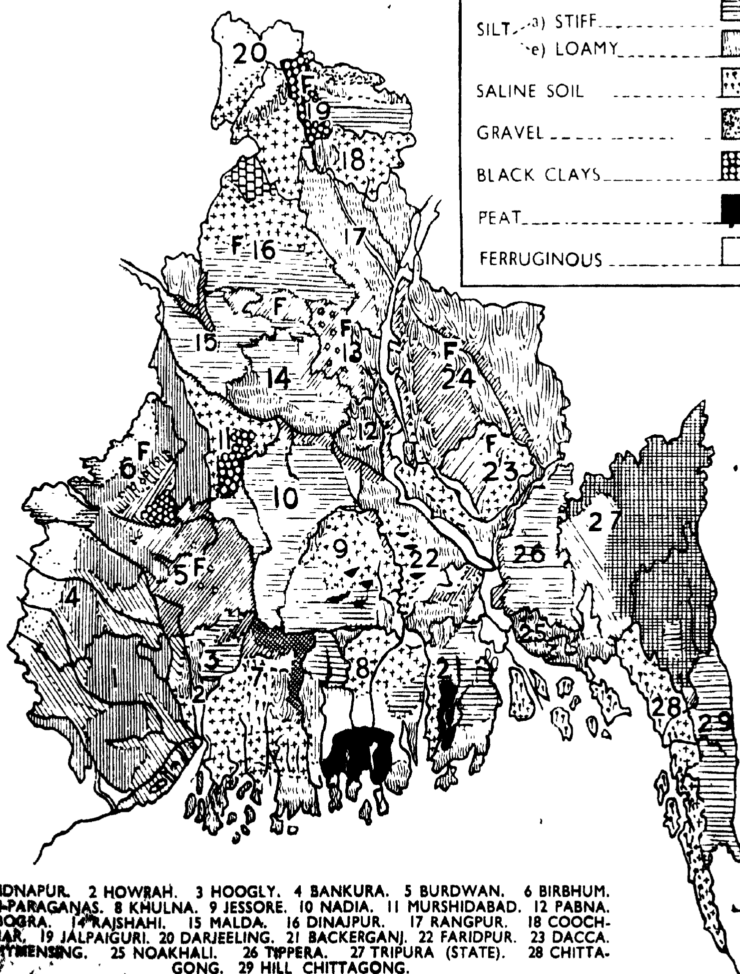
THE GENERAL NATURE OF THE SOIL OF THE DISTRICTS OF BENGAL

(ACCORDING TO DT GAZETTEERS)

BENGAL

SCALE = 1-INCH = 336 MILES

METAMORPHIC ROCKS	
LIME-STONE	
HARD SEDIMENTARY ROCKS	
OLDER ALLUVIUM	
NEWER ALLUVIUM	
LATERITIC SOIL	
LOAMY	
CLAYEY	
SAND OR SANDY SOIL	
WITH KANKAR	
SILT (a) STIFF	
(e) LOAMY	
SALINE SOIL	
GRAVEL	
BLACK CLAYS	
PEAT	
FERRUGINOUS	F



1 MIDNAPUR. 2 HOWRAH. 3 HOOGLY. 4 BANKURA. 5 BURDWAN. 6 BIRBHUM. 7 24-PARAGANAS. 8 KHULNA. 9 JESSORE. 10 NADIA. 11 MURSHIDABAD. 12 PABNA. 13 BOGRA. 14 RAJSHAHI. 15 MALDA. 16 DINAJPUR. 17 RANGPUR. 18 COOCH-BEHAR. 19 JALPAIGURI. 20 DARJEELING. 21 BACKERGANJ. 22 FARIDPUR. 23 DACCA. 24 MYMENSING. 25 NOAKHALI. 26 TIPPERA. 27 TRIPURA (STATE). 28 CHITTA-GONG. 29 HILL CHITTAGONG.

germinate first in the beginning of rains into hyphæ and then the mycelium gives rise to sporophores towards the end of rains.

The ecology of *Polypores* which is at present very little worked out offers a very promising field. Brooks (15) has appropriately pointed out that in ecology generally the factors of competition and the influence of one plant on another have long been held to be of supreme importance. This influence of micro-organisms on one another, as he has stated, may be mutually helpful, or distinctly antagonistic, or entirely indifferent to one another. As an example of the first case he cites a tree-log on which a succession of different fungi usually develops in orderly sequence over a period, one species apparently preparing the way for the other. The antagonistic influence is shewn when a tree-stump permeated in nature by one *Polypore* prevents the development of another *Polypore*, though in nature both these fungi are widespread and can be easily grown in culture on the same tree wood in the laboratory. Similarly Brooks has noticed how the occupation of exposed wood in plum trees by comparatively harmless micro-organisms tends to prevent subsequent invasion by the dangerous *Stereum purpureum*. In Japan, Endô (25) has studied the morphological changes of mycelia of the pathogens in the presence of the antagonistic bacteria ; these hyphal deformations are similar to those observed in the case of application of the various preventive chemicals. This branch of study demands a continuous record of the climatic and soil-conditions and of the succession of the prevalent specimens for a number of years in one particular area.

General nature of the soil of the different districts of Bengal.

A glance at the attached map shows the districts of Bengal in various signs which correspond to the different kinds of soil as indicated on the left hand side of the map. This soil-map of Bengal is based on materials available from the district gazetteers. It should be noted that under the head *Newer Alluvium* come such soils as loamy, clayey, sandy, saline, and silt. But where such details are not available, the country is simply indicated as belonging to the Newer Alluvium. The boundary of the different kinds of soils within a district is more or less conjectural.

Fossil records of Polyporaceæ.

The fossil records of *Polypores* are very few ; in most cases only the mycelium was found preserved within the fossil wood in petrified vegetable structures of varied types from Devonian times down ; regular fructification was absent as it was held that the cap or pileus is hardly preserved in the fossil state.

Dr. Hirmer has recorded (38) that there are few fossil records of *Polyporaceæ* (a few *Polyporus, Fomes, Trametes, Daedalea,* and *Lenzites*) and that they are mostly of the tertiary period, very few being of the Carboniferous age. He has noted that *Fomes pinicola* was known from the 'Quartaren Kohlen'.

Buchwald reported in 1930 and 1934 (17 and 18) that fossilized fruit-bodies of *Polyporus fomentarius* (L.) Fr., the tinder-fungus, have been found in 16 different localities in Denmark—in the Danish postglacial peatbogs, a few times also in the deposits of the Stone-Age, when it was already used as tinder. He holds that these fossil specimens were erroneously referred by E. Rostrup and others to *Polyporus igniarius* (L.) Fr. and *P. nigricans* Fr., that they are the species of *P. fomentarius* (L.) Fr. Very recently (66), Dr. G. R. Wieland of Osborn Bot. Laboratory, Yale University, has recorded a silicified *Polypore*-fructification from the lower Cretaceous of Montana. He notes there an 'unexpected find of a small but beautifully silicified shelf- or bracket-fungus found by Mr. Barnum Brown lately while collecting armoured dinosaurs in the Cloverly horizon of the lower Cretaceous along Beauvais Creek on the Crow Indian Reservation, about 40 miles south of Billings, Montana. The locality is near the "Bill Cashen rauch" and yields some twelve skeletons of dinosaurs of varied form and remarkable type. It is indeed curious to thus see with certainty a mushroom very much as it grew in life on the trees of the forests of those remote dinosaur-times. We may assume that the climate was warm, that ancestors of the *fig* and *magnolia* were there, and this fungus grew on the bark of such trees, or perhaps on some *Conifer*'. He has named it *Polyporites browni* n.sp., a very rare and finely silicified *Polypore, Polyporites* meaning fossils demonstrably like *Polypores*. At p. 12 he notes further 'Mr. Brown has now found south of Harlowton, Montana, an additional fungus quite identical with that here described. Associated vertebrates and invertebrates are identical with those of the Cloverly north of the Pryor-Big Horn Mountains. Hence these unusual silicified shelf-fungi must be for their horizon far from rare, and may evidently be found along a considerable range of the Cloverly terranes'.

MORPHOLOGY AND SYSTEMATICS.

The systematic work constitutes the basis of all comprehensive works, and in most cases it is after this that the real intensive study begins. This systematic work should therefore be thorough and critical; with this idea in view I began by describing fully about 125 species collected from various parts of Bengal, paragraphing the different features with a note on the distribution of the species, and by publishing them serially in local journals under the heading, *Polyporaceæ* of Bengal parts I to X (1918 to 1934), with photo-plates of the two surfaces

of each species. Doubtful specimens were named with the kind help of distinguished mycologists of Europe and America. In 1923-1924 I had the opportunity of visiting European herbaria and of personally working on some of my doubtful specimens at the mycological herbaria of Paris, Berlin, Kew, and the British Museum (Nat. Hist. Sec.), London.

On the necessity of redescription Dr. C. L. Shear (58, p. 204) remarks so recently as May 1934, that 'one of the present needs is a thorough study and redescription of all the available type or authentic material of the species of fungi of older authors, a very large number of which are at present imperfectly known or misinterpreted. Probably, not one-fourth of the species found in Saccarodo's "Syllogoe Fungorum" are well enough described or known to be identified with certainty. As the old species are more fully known and recognized, a great number of our recent so-called new ones will fall into synonymy. The names at present in general use should be conserved'. I entirely agree with this observation. Miss Wakefield spoke almost in the same strain (63) that 'some of Fries' introductory remarks concerning the variability of species of *Polyporaceæ* and his doubt as to the value of numerous species which had been proposed from the examinations of single specimens might well have been written at the present day'. The genera of *Polyporaceæ* are usually *Polyporus*, *Polystictus*, *Trametes*, *Fomes*, *Ganoderma*, *Lenzites*, *Daedalea*, *Hexagonia*, *Favolus*, *Merulius*, and *Poria*. At present the generic distinctions within *Polyporaceæ* are very much ill-defined ; with small collections and limited experience it may not seem difficult to separate these genera but, with abundant materials drawn from a very wide range of localities, many varieties and intergrading forms are found which become difficult to locate satisfactorily.

ANATOMY—THE BASIS OF RECENT CLASSIFICATION.

With the development of mycology, increasing importance has come to be attached to anatomical characters in the classification of the fungi. In some cases characters of spores and basidia and other hymenial characters have been found very useful in the demarcation of species. The old classification of Fries was founded mainly on external characters. The morphology of the basidium in the classification of the Basidiomycetes was first used by Tulasne (1851). In 1889, Fayod (26) made extensive use of anatomical studies in the classification of Agaricaceæ. Then, Patouillard in 'Essai taxonomique sur les familles et les genres des Hyménomycètes' in 1900 formulated a scheme of classification of the Basidiomycetes based on a study of the basidium and other microscopic characters. Bourdot and Galzin (11) have amplified the concepts

of Patouillard in further critical rearrangement of old as well as new fungi ; Donk (24) is also revising the whole Dutch groups of homo- and heterobasidiomycetes in the light of detailed anatomical study. Albert Pilát of Prague is bringing out a monograph of European *Polyporaceæ* in series, of which the first part appeared in 1931. Rogers (54) has discussed the probable origin of the typical homobasidiomycetes through transitional forms. Rea (51) in his 'British Basidiomycetæ' has followed mainly Patouillard's classification, as this classification shows more clearly the true relationships between the various families and genera. In this connection it is interesting to quote the recent remark of Dr. Cleland (20) of Australia in June 1934, 'Though agreeing as to the correctness of the classification that Rea adopted in dealing with the *Agarics*, we have decided as a matter of convenience to follow the older method of classification'. Rogers (*loc. cit.* at p. 176) also holds that Patouillardian categories are unquestionably more difficult to follow in keys than Friesian. This newer classification is certainly an improvement on the old Friesian system of classification and brings together nearly related genera which were formerly kept apart on the basis of external morphology alone. But I feel we must go deeper into the anatomy-study of sporophores of *Polypores* than the study of mere basidia and spores ; we must take into account Overholts' work (46) on hyphal diameter, colour, septate or aseptate condition of the hyphæ, branching and the manner of growth of the context-hyphæ of the sporophores and on hyphal pegs in thin *Polypores* (*Polystictus*), Corner's work (22) on skeletal, binding, and generative hyphæ in sporophores, and the recording of the presence or absence of clamps in the generative hyphæ, the presence of encrusted cystidia or cystidia-like projecting hyphæ in some species, the shape of cystidia and setæ, etc. In some cases I have seen that the thickness of the wall of the hyphæ of the context of the sporophore may be of some help in separating the closely related species of *Polyporaceæ*. Thus, *Polystictus personatus* is distinguished from *Poria diversiporus*, *Polyporus cervinogilvus*, and *Polystictus Berkeleyi* by having its characteristic double-walled hyphæ about 4μ broad in the context. I entirely agree with the following observation of Ramsbottom (52) that 'Systematic species were at one time defined on purely morphological grounds, these must still remain the unit of classification but such species should be precised by study of anatomical, cytological, cultural, physiological, chemical, and other characters'. Melzer and Zvara have made use of chemical reagents in classification of *Russula*. They base their classification on colour-reactions which are said to be constant. Iron-sulphate is used for the colour-reaction of the flesh of the fungi and chloral iodine, for the examination of the spore-wall. Roger Heim and J. Duché of the Paris Natural History Museum have

utilized the characters of smell in the classification of some genera of *Agaricaceæ* and *Actinomyces* respectively. E. J. Gilbert (31) under the heading of 'Osmologie mycologique' has classified odours emitted by different species of *Agarics* and some *Polypores*. Kühner (42) has shown how localization of pigments or coloured substances (whether on the wall or inside the cytoplasm) may be of use in the classification of *Agarics*. My considered opinion is that we should not change the old classification, however imperfect, till we have accumulated data from the completed study of these diverse aspects of *Polyporaceæ*. How appalling is our ignorance of the special biology and anatomy of the *Polypores*! The sheer weight and magnitude of the subject, I think, should compel a healthy specialization, though older Botanists might deplore it as some people deplore the good old days when a naturalist was expected to teach Geology, Zoology, and Botany as a matter of course.

General structure, Nutrition, Cytology of reproduction and the Chemical nature of the fruit-body of *Ganoderma lucidus*.

The general structure of *Polypores* might be divided into two parts, (*a*) the vegetative and (*b*) the reproductive. The vegetative portion consists of delicate threads of mycelium buried in the substratum on which the specimen is growing, and its use is mainly the collection of food for the plant. Most of the *Polypores* are saprophytes growing on logs, dead trunks and branches, and dead bark, living upon their dead tissues. Some are wound-parasites, attacking a root at the collar or the trunk near its base after which they work inwards into the heart-wood and thence proceed upwards, the decay extending outward into the lower sap-wood. Some are parasites also, attacking living plants—their roots, stems and branches. According to some, the best criterion for the parasitic nature of the attacking fungus is the presence of a brown band, which marks the limit of the advance of the fungus. The microscopical examination of the brown discoloured band reveals the presence of the wound-gum and tyloses. Munch (45) holds that the wound-gum originates after the death of the cells attacked as an oxidation-product of their contents, usually accompanied by the disappearance of starch from the medullary ray-cell. Tyloses, on the other hand, are produced by the living cells which are stimulated by the attack of the fungus.

All kinds of cells are not equally acted upon; sometimes the cells of medullary ray remain intact but the wood-cells are completely destroyed, in other cases wood-cells remain intact while the medullary ray-cells are gone. There is also a difference in the mode of attack on the wall; some dissolve the middle lamella, the cementing substance, thus making the

cells fall apart before the cell-walls are destroyed, while others attack from outside, falling first upon the tertiary layer (the layer bounding the cavity) and then upon the secondary layer and finally upon the middle lamella. Different kinds of *Polypores* are very variant as regards their action on different kinds of cell-walls. They utilize different kinds of enzymes for this purpose ; some, for instance, can dissolve the lignin and pectic substances but have no action on cellulose, some take away cellulose from the tertiary layer but the lignin and pectic matters (middle lamella) remain unaffected, others, again, corrode the wall uniformly from within out, leaving the middle lamella almost in the original condition.

The reproductive portion consists of the fruiting body known as cap or pileus, sometimes with a stalk, sometimes without any. The stalk is usually lateral with the exception of a few species of *Polystictus* and *Polyporus* (like *Polystictus xanthopus, Polyporus friabilis, P. agariceus, P. brumalis,* etc.) where the stalk is almost central. The pileus shows two surfaces, the upper or the exposed surface and the lower or the protected one (known as hymenial surface), bearing the hymenium consisting of a number of pore-tubes. The hymenial surface shows externally a number of pores of various sizes ; the basidia arise directly on the side of these pore-tubes and each of the basidia is surmounted by four sterigmata, each of which bears a spore. So, we get four spores from a basidium. These spores are quite exposed and, when ripe, are set free and carried by various agencies, viz. by currents of air, water, floating timber, flies, mites, snails, birds, and by transport through human agencies to distant parts, where falling on an appropriate surface they germinate and give rise to the particular species. Some of the basidia do not bear spores and are known as paraphyses ; some again become large and projected like a flask from the level of the basidia and are known as cystidia. Some species of *Polypores*, especially the coloured ones as *Fomes senex, Fomes pachyphalaeus, Polyporus gilvus,* etc., show in the section of the pores a number of short spines arising from the walls of pore-tubes ; these are known as setæ and they are of great help in the determination of species. According to L. O. Overholts (47) cystidia are usually hyaline, they are called setæ when they are brown and sharp-pointed. Paraphyses can be usually distinguished from cystidia by the frequency of their occurrence as they usually alternate with the basidia, while cystidia or setæ are scattered irregularly through the hymenium. According to Buller (19) the position of the hymenium on the underside of fruit-bodies has been decided by the necessity of the basidia being so placed that they can readily liberate spores into the air.

The reproduction of *Polypores* is usually by means of basidiospores ; in some cases it is by means of conidia or secondary

spores. The discharge of spores is enormous and, especially in the case of perennial species, continues for some time like a cloud coming out from the hymenial surface. This was clearly seen in the case of *Fomes pachyphalaeus* growing on the famous Banyan tree of the Shibpur Botanical Gardens and on another Banyan tree in the Jessore district, Bengal. It was observed that smoke came out of these specimens for two or three years (from 1921 and 1931), and, when they were brilliantly illuminated by rays of light penetrating through the dense foliage, the cloud of spores was distinctly visible.

The cytology-study of tramal hyphæ, the sub-hymenium and the basidia of a number of local *Polypores* was made after fixing in Bouin's fluid, Fleming's strong and weak solutions and Regaud's fluid. Paraffin-sections were usually cut 5μ thick and were stained with Heidenhain's Iron Hæmatoxylin. It was found that the tramal hyphæ and the basidia were regularly binucleate; the two nuclei in the basidium coming into contact with each other, gradually fused into one large fusion-nucleus with two prominent nucleoli. The fusion-nucleus then passed through two quick divisions—usually first meiosis and then mitosis, the basidium thus became tetranucleate. By this time four sterigmata were formed at the apex of the basidium and the nuclei were seen migrating constricted through narrow arms of the sterigmata and ultimately formed the nuclei of the terminal spores. In some cases (*Polystictus versicolor*) the nucleus of the spore underwent division into two and thus spores were binucleate. The long axis of spindle was usually transverse, but in some cases the spindle was formed in an oblique and almost longitudinal plane. I am in entire agreement with Vokes (60) that the long axis of the spindle has no definite orientation in either division. Thus, the process of nuclear divisions in all its stages has been followed and it corresponds fundamentally to meiosis in higher plants; but the number of chromosomes being extraordinarily small they could not be satisfactorily counted; they seemed to be two in some cases. But on this point I am afraid I cannot now be definite. Wakayama (61) has counted them as varying from 2 to 6 in some of the *Polypores* he has examined. This process of nuclear fusion in the basidium followed by divisions is regarded as a very much simpler type of fertilization prevalent in the higher fungi.

With Regaud's fixative minute mitochondrial bodies in the basidia of *Polypores* came out very clearly but no plasts (filamentous bodies), however, were visible.

The vacuolar bodies within the basidia of some common *Polypores* were studied with the help of the special methods of Golgi, Kolatchev, Bensley, Weigel, etc.; the control-method of vital staining with neutral red was also carried out. To me it seems that the vacuolar bodies in basidia of *Polypores*

correspond to Golgi-bodies so often described by Gatenby in animal cells and that the solid Golgi-elements are nothing but artifacts due to the excessive precipitation of metallic silver or osmium inside the vacuoles, as observed by me (6) in 1929 in 'Annals of Botany'. A recent account (apparently preliminary) of the 'nebenkern' and the Golgi material in *Corpinus sterquilinus* by J. E. Sass (55) does not seem to be very convincing, as there was no control experiment of vital staining and the results figured in his plate could be obtained, according to the author's admission, with only few out of the several fruit-bodies examined. Vokes' work (60) on *Corpinus atramentarius* also does not show any nebenkern or Golgi material by the side of the fusion-nucleus in any of the basidia.

The chemical nature of the fruit-body of Ganoderma lucidus.

The chemical analysis of the sporophore of the well-known species 'Ganoderma lucidus', an almost cosmopolitan species with a strongly laccate upper surface, was kindly carried out at my request by Dr. Julius Zellner (68) of Vienna. The mineral content of the fungus amounted to 5·57% of the dried substance. The organic matter was partly soluble in ether (4·03%), in alcohol (3·06%) and in water (5·47%). The ether-extract of the fungus was found to contain ergosterin and gave indication of the presence of fatty acids. The alcohol-extract was found to contain mannite and the aqueous extract contained polysaccharides precipitable by alcohol and a voluminous deep-brown amorphous substance much resembling humus acid, which was precipitable by means of inorganic acids and which forms a common constituent of many ligneous *Polypores*, viz. *Polyporus* (*Fomes*) *igniarius*, *F. fomentarius*, *P. hispidus*, etc. The fungus also contained a quantity of resinous matter amounting to 1½% of the air-dried fungus but the exact chemical nature of the resin could not be determined. The major portion of this resinous substance was soluble in alcohol and the rest in ether.

BIOLOGICAL PECULIARITIES.

(*a*) *Habitat.*—In connection with the general structure I have incidentally dealt with some of the biological peculiarities of *Polypores*. As regards habitat, it is usually found that some species grow singly on logs or trunks and branches of forest-trees, while others have a gregarious habit. The decays in wood according to the gross characters of the rot are known as *white rots* and *brown rots*, depending on the colour; in the former case the wood becomes lighter in colour and in the latter it acquires a dark-brown or reddish tinge. Fisher (27) has recently shown that the old notion of the softening of the wood

in the 'white rot' stage of decay as due to *delignification* is not correct, as the chemical analysis shows that it is the cellulose which has been removed and not the lignin. In the final stage of decay, the dense masses of hyphæ become converted into finer elements till they disappear entirely due to starvation and gradual death of the fungus. Rhoads (50) has shown that the formation of black zones in the wood attacked by *Polypores* is due to the conversion of the carbohydrate substances, particularly the hemicellulose xylan, into humic substances of two principal groups, namely humic acid and humin, and these humic substances gradually accumulate and give rise to the dark-brown decomposition-products which are of such common occurrence in the decaying wood. Again, such humic products arise under certain circumstances in wounded parts of living trees or in fallen woody plants that are entirely free from fungus-attack and which are known under the name of 'wound-gum'.

(*b*) *Adaptation.*—The particular appearance of a species depends on the peculiar environment and hence we meet with a number of abnormal forms and monostrosities in cases of specimens growing in dark closed places. This I have seen in cases of *Polystictus hirsutus* growing within hollows of dead bamboos, of *Lenzites repanda*, *Fomes lucidus*, *Fomes leucophaeus*, etc. growing on logs lying in dark protected places; they usually assume in such cases the form of a round ball. The innate tendency amongst the *Polypores* as well as the whole *Hymenomycetous* subclass is to secure a protected hymenium on the lower surface so that the pore-tubes remain almost always pointed downward for the effective discharge of spores. In several cases I have obtained direct evidence that the development of sporophores is greatly influenced by gravity; if, by accident, the position of the log becomes inverted and the upper surface of the pileus is turned downwards, the hymenium begins to develop on the former upper surface, which now points downwards, till it becomes changed into a complete pore-bearing surface.

Some like *Trametes meyenii* and *Polystictus sarbadhikarii* have corky or leathery fruit-bodies, by means of which they can dry up without any loss of vitality; others have hairy or soft and velvety upper surface (i.e. *Polystictus hirsutus*, *Polystictus versicolor*, etc.). As soon as the rains begin to appear, they set forth an advancing zone which is quite marked off from the old zone. Two or three such annual zones, succeeding one another and showing two or three periods of growth, can be easily seen in cases of *Polystictus hirsutus*, *Polystictus versicolor*, *Trametes meyenii*, *Ganoderma lucidus*, *Fomes senex*, etc. In the case of perennial *Fomes* the different annual zones are usually in superposed layers and hence a section of it usually shows a number of stratified pore-tubes; usually

after one period of growth in some cases the mouth of the pore-tubes becomes closed by thin layer of context on which the pore-tubes of the next period appear, which become similarly closed and so on. Well-marked variations of the pores in the hymenial surface of *Polystictus xanthopus* and *Polystictus flabelliformis* at high altitudes have been recently noted by me (10).

One of the most important problems is the study of the dormant, resistant mycelia able to withstand unfavourable conditions in a quiescent stage. Every summer a critical change takes place in the affairs of most species of fungi common in tropical countries like Bengal and preparations are made to withstand the unfavourable conditions; most of the species die and a few survive leaving dormant mycelia. As I have remarked elsewhere, as soon as favourable conditions are renewed with the advent of rains they at once show vigorous growth and renewed activity, soon leading to the development of sporophores; that is why we suddenly meet with a number of species in the rainy season from unexpected places. Of course, the critical change does not take place at the same time of the year in the case of all species in different parts of Bengal and there is considerable specific idiosyncrasy as regards the biology of *Polypores*. Some mycologists have suggested that the appearance of certain species is periodical and fixed, say, at periods of three years, etc. We have no precise information on this and similar other points, viz.—How do the species in any given locality vary from year to year? What species occurs only rarely? How does a species vary in a locality according to the season? In *Sálwoods*, *Segunwoods*, Pinewoods or other formations, how do the several species follow one another in succession from one season to another? What species are common to more than one formation? What are the limits of variation in size of a given species? What is the host-range of Polypore-species? These are fruitful lines of inquiry that remain yet unexplored. Local Natural History Clubs can carry on very valuable work in this line, when supported by enthusiastic and keen collectors of local flora.

The general biology of *Polypores* is fairly well-known. Some *Polypores* begin their lives as saprophytes, attacking dead roots, stumps and branches, they then extend their hyphæ round the living cells in the adjoining portions and thus become converted into parasites. Others begin their lives as parasites, their spores usually entering through a wound, then they kill the living portion and finally establish themselves as saprophytes with a number of sporophores on dead parts of the plants. In extreme cases the whole central cylinder (heart-wood) is destroyed, converting the tree into hollow structure. Some, again, rarely continue their activity after the tree has been cut and converted into timber.

Some like *Fomes lucidus* have two forms, sessile and stalked. Stalked variety of *Fomes lucidus* is found on bamboo-stumps and palm-stems (usually on *Monocot.s*) and we get sessile forms usually on *Dicot.s.*

Some species of *Polypores*, as has been already remarked, appear later in winter provided the substratum has been sufficiently moist for the growth of the mycelium within. This evidently shows that for them at least the temperature is not so important as the moisture. On the other hand, *Polypores* cannot grow in the total absence of air, for instance, on submerged pieces of wood. After the dry season it takes several weeks of steady rain for a fruit-body of *Polypore* to appear above ground and a single heavy rainfall is not enough; this again shows that time is also an important element. The exact combination of time, moisture, and temperature necessary for the growth of *Polypore*, is, however, difficult to determine. The mycelium must be sufficiently well-developed before it has enough energy to produce fruit-bodies, and this development is exceedingly slow for reasons difficult to ascertain.

Polypores, like other fungi, are active agents of decay and are very effective in causing total disintegration of the dead vegetable matter; bacteria usually appear in the later stages of decay. In the case of wood it is the sapwood which is more easily decayed than the heart-wood chiefly because the cells of the heart-wood do not contain any food and their walls are toxic to fungus-growth.

Some *Polypores* show a selective preference for a certain substratum which may be dead parts of a tree, wood or soil containing decaying vegetable matter. This specificity of saprophytism, according to Brooks (15), may probably be due to the antagonistic influence of one fungus upon another, the first organism may exercise some toxic influence on the other or it may utilize the available food-material so rapidly as to starve the second organism.

The parasitic species usually attack the roots and stems of living trees and shrubs and very rarely herbs. The trees attacked are impaired and, even if not killed by the fungi, are evidently blown down by storm.

(*c*) *Spore-discharge in Polypores.*—There is considerable idiosyncrasy regarding spore-fall in detached fruit-bodies of *Polypores* in the laboratory. Much depends, of course, on the individual constitution and the period and mode of desiccation. I have observed that dried fruit-bodies without basidia do not discharge spores even if they are kept under moist condition. Probably in such cases the connection with the substratum is necessary for the purpose of food-supply and for revival with the formation of new active basidial layer. Dried fruit-bodies with basidia, moistened with wet cotton-wool at the top, usually shed spores under the moist condition in the cases of thin

specimens of *Polyporus*, *Polystictus*, *Trametes*, *Haxagonea* and *Daedalea*, after varying periods of desiccation (weeks, months or years). In this condition I have observed the revival of old dried basidia as well as in some cases the formation of additional basidia from the same old hymenial layer; but I could not observe any new hymenial layer. In some cases (*Lenzites repanda* in December 1931 and *Polystictus hirsutus* in January 1932) I have seen fresh growth of tube-lengths above the old pore-tubes after a week, when a piece of the sporophore was kept within a moist agar plate by sticking it to the upper lid of the plate so that the spores dropped direct on the agar medium. Here the older portion of the pore-tubes had almost lost basidia and spores, only the newer portions were full of basidia with attached spores, and the spore-fall period prolonged for twenty-nine days continuously. In one case I have seen the spore-fall continued for nineteen days at a stretch, then there was a pause for seven days, and again the spores were discharged for the second time for twenty days continuously, the specimen being kept in the same moist condition throughout. In the case of only two fresh specimens of *Polyporus ostreiformis* collected during the rainy season, there was a side-growth of pore-tubes on all sides of the piece attached to the agar-plate and copious spore-fall continued both from the new as well as the old parts. Sporophores of a good many dried and thin *Polypores* with basidia did not shed any spore under the same moist condition. Evidently, they did not survive desiccation, though their basidia had not yet collapsed; for a living specimen is sure to throw out spores when revived. Buller (19, pp. 110-111) has recorded that fruit-bodies of some of the *Polypores* revived after more than two years, and of one *Daedalea unicolor*, after more than four years, but he has not examined the basidia in these fruit-bodies.

Xanthochroic *Polypores* (*Fomes senex*, *F. pachyphlaeus*, *F. pinicola*, *Polyp. gilvus*, *Ganoderma lucidus*, *Ganod. applanatus*, etc.) do not survive desiccation long, when detached from the substratum; they shed spores only for a short time in the fresh condition. *Ganoderma* specimens collected fresh during the rains, though full of basidia and spores, very rarely discharge their spores when kept at room-temperature (30°C.) under artificially moist condition. I tried the effect of incubator-temperature at 37°C. with no better result. After repeated attempts for a number of days during the whole rainy season, I was fortunate enough to observe spore-fall in two or three instances only (August and September of 1931).

In spite of my repeated attempts, I could obtain no evidence of the progressive exhaustion of basidia and spores successively from the base to the mouth of the pore-tubes in ordinary cases of spore-fall where there was no fresh addition to the length of the pore-tubes. In a *Fomes senex* collected on 19th February,

1933, from the trunk of a living *Ficus religiosa* tree, I could observe spore-discharge from the young tubes near the margin full of active basidia, but the old tubes near the base were filled up with stuffing hyphæ, their basidia developing pale yellowish walls and becoming cemented together to form a pavement-like layer. Prof. Buller has observed successive generations of basidia coming one after another quickly from the tramal hyphæ in some *Agarics* like *Corpinus*, etc., where the life-history of the species is short; but in *Polypores* with comparatively much longer life-history I have never observed more than one generation of basidia in one period of growth. Another difference from a common *Agaric* is that old basidia of some *Polypores* do not at once collapse after the discharge of spores; they remain probably at a stand-still for some time. In this connection one curious fact I have noticed is that specimens of *Ganoderma lucidus*, full of basidia when conserved in the herbarium, ordinarily get their basidia collapsed in the course of three to six months, but in two exceptional cases (our herbarium specimens) the basidia were in perfect condition for more than *three years* in the herbarium without any sign of collapse, fully crowding the cavity of the pore-tubes. Of course, such herbarium-specimens of *Ganoderma* never shed any spores.

I have noticed (8) that specimens of *Polyporaceæ* are usually full of basidia during the rainy season; after the rains (usually from November and December) the basidia in living and growing (in nature) specimens of *G. lucidus* and *G. applanatus* are succeeded by hyphæ projecting direct from the trama and bearing secondary spores at their tips, which are indistinguishable from the ordinary basidio-spores in any way; probably, these carry on spore-discharge in the dry season. In one instance, I have seen that from a fruit-body of *Trametes lactinea* collected in December 1931, where there were no basidia but only tramal hyphæ-projections within the pore-tubes, a large number of spores dropped on the agar-plate though there was no revival of any basidia under the moist condition. In a private communication to me in May 1932, Rev. Bourdot also cited some instances where he could get spore-discharge, though not a single basidium was visible under the microscope. In *Xanthochrous patouillardii* Rick var. *congoensis* Pat. et Heim, Heim (36) has noted recently in 1933 such tramal hyphæ-projections bearing terminal secondary spores indistinguishable from basidiospores beside the basidia within the pore-tubes. In November 1931, I observed that after an unexpected shower of rain specimens of *Ganoderma* which had their basidia almost replaced by direct tramal hyphæ, reverted to basidia-formation. I have just published in 'Phytopathology' (April 1935) the cytology-study of the secondary spore-formation in such hyphæ where I have shown that secondary spores seem to be formed by way of amitosis. In several instances of common local

Polypores, I have noticed usually in November and December such tramal hyphæ-projections within the pore-tubes bearing terminal rudimentary spores. In the case of *Polypores calcuttensis* Bose, I noticed hyphal projections also from the basidial heads, besides those direct from the trama.

Some species of *Polypores* [viz. (1) *Polyporus luzonensis*, (2) *Trametes lactinea*, (3) *Lenzites repanda*, (4) *Fomes senex*, (5) *F. tricolor*, (6) *F. rimosus*, (7) *F. fastuosus*, (8) *F. pachyphlaeus*)], after the rainy season is over, close up the openings of the pore-tubes by outgrowths of stuffing hyphæ from the trama in the form of a net. It seems a specific character, present in some and absent from many others.

PHYSIOLOGY OF POLYPORES. (*a*) LIFE-HISTORY STUDIES IN ARTIFICIAL CULTURES. (*b*) MONOSPOROUS CULTURES, THE STUDY OF HETEROTHALLISM AND THE PROBLEM OF SEX IN FUNGI. (*c*) ENZYME-ACTION OF SOME LOCAL POLYPORES.

(*a*) Life-history studies in artificial cultures of more than a dozen of our local *Polypores* have been carried out and were published by me (5) in 1930 in the journal of the Linnean Society where, under the heading of general remarks, I have considered at some length the peculiarity of the germination of basidiospores and the presence of basidia within the sporophores, the influence of gravity on the formation of pileus, the influence of sunlight on cultures, the location of sporophores in culture-media, the density of the mycelium and the sporophore-formation, the length of the life cycle in different media, the development of true pilei in artificial cultures and the nature of the media favourable for the sporophore-formation of these *Polypores*. The spores of some *Hymenomycetes*, especially the coloured varieties, are difficult to germinate; in others, though the spores germinate, it is difficult to obtain the final fructifying stage. No satisfactory explanation of the cause of this failure can at the present stage be offered. Fresh sporophores collected during the rainy season are usually full of basidia. So also are *Ganoderma* specimens during the continuous rains. Otherwise, that is, unless collected at the proper humid season, it becomes difficult to find basidia in sporophores. Basidia collapse sometime after the discharge of their spores. In the case of the perennial species we have no direct observation as yet whether the same hymenial layer functions each year by the pushing up into it of new basidia developed from the subhymenium. In case of the cultures exposed to the diffused chamber-light, it was found that the general effect of light seemed to check the vegetative growth which was ultimately followed by the sporophore-formation. In most cases of

sporophore-formation within the culture-tubes, it was noticed that they were formed on the upper end of the slant towards the glass surface, that is, almost always away from the moist agar-surface towards the drier air at the margin of the culture, and that they were often associated with a poor vegetative mycelial growth. It has been rightly remarked by Klebs (40) and Robinson (53) that there is an antithesis between the vegetative growth and the reproductive activity ; this holds good generally in green plants also. In artificial cultures of *Polypores* on blocks of wood, the length of the life cycle was prolonged, while in the tube and plate-cultures in malt-extract-agar medium it was much shorter. Typical pilei are hardly formed in artificial cultures ; in some cases only the hymenial surface with characteristic pore-tubes is formed, in others an elongated patch consisting of shallow pores and recalling the structure of the genus *Poria* is formed, as noted by Baxter (2). These *Polypores* can fruit on a wide range of media irrespective of their special host. No special decoction is necessary for their sporophore-formation. In the present case almost all of them fruited in malt-extract-agar medium.

(*b*) In *La Cellule* in March 1934 (7), I published the results of my study in detail of the sexual reactions of two of our common *Polypores, Polyporus ostreiformis* and *Polystictus hirsutus*, by a large number of monosporous cultures and of their pairings. They show that both are strictly heterothallic and bisexual species. The addition of minute doses of poisons and of acids to the culture media, which were inoculated with monosporous as well as bisporous mycelia of both the species, did not produce any change either in the original sexual reaction or any saltation or mutation of the monosporous mycelia. This is quite contrary to the experience of Heldmaier (37) in the case of two soft *Agarics, Collybia velutipes* and *Schizophyllum commune*, and of Gates (29) in the case of Mucor. Monosporous cultures, exposed to variations of temperature and of light and darkness and growing in different kinds of nutritive media, did not mutate from the haploid to the diploid state, though they were kept under observation for over two years.

There I remarked that from a survey of these results one feels tempted to suggest the possibility that with hard fungi, such as *Polypores*, which might be regarded as the biggest forms among the fungi in terms of rigidity and solidarity, the two sexes are of a stable character and not easily interchangeable as is the case with the various groups of lower fungi examined by different workers from time to time. Mounce's (44) experience with *Fomes pinicola* also points in the same direction. In this connection one may be permitted to point out an analogous case in the animal kingdom where the sexes of the higher animals are not easily interchangeable while the lower animals of the order of insects can be easily converted from one sex

into the other through the nutritional state, as has been pointed out by Holdaway (39).

As I think, altogether about a dozen species of *Polyporaceæ* up to now have been studied by different workers (Mounce, Robak, Vandendries, and Bose), all showing heterothallism. Of these, eight—*Polyporus ostreiformis*, *Polyporus anceps*, *Polystictus hirsutus*, *Fomes pinicola*, *Fomes roseus*, *Leptoporus imberbis*, *Lenzites sepiaria*, and *Trametes protracta*—are bisexual, and seven—*Polyporus borealis*, *Trametes suaveolens*, *Trametes hispida*, *Trametes cinnabarina*, *Lenzites betulina*, *Polystictus versicolor*, and *Coriolus zonatus*—are quadrisexual.

Problem of sex in fungi.—Wager (62) has pointed out that a normal sexual fusion (fertilization) includes at least two distinct phenomena—(1) the blending of the parental characters derived from two distinct lines of descent and (2) the rejuvenescence of the reproductive cell by means of which it receives a new stimulus to growth and division. In the higher fungi, this normal type of sexual fusion has disappeared, and it has been replaced by a simpler type of nuclear fusion—*endokaryogamy*—the purpose of which is to provide for the nuclear reorganization and reinvigoration of the individual reproductive cell just at the time when large numbers of spores are about to be formed. Here we have no blending of two lines of descent but simply a recombination of nuclei, which had become more or less differentiated in the individual, for restoration of the vigour necessary for further development. Later on, he remarks that fertilization is not an essential factor in reproduction, that in certain forms of lower animals fertilization may be replaced by stimuli of various kinds and that unfertilized ova of the silk-moth can be stimulated to develop by rubbing them with a brush or dipping them for two minutes in sulphuric acid and then washing them. Loeb has given numerous examples of substances—hypertonic sea-water, solutions of magnesium chloride, sugar, potassium salts, inorganic acids, calcium salts, fatty acids, etc.—all of which are capable of effecting division in non-fertilized eggs. In the case of yeasts, the unicellular fungi (one of the lowest forms of plant-life), Winge (67, p. 107) remarks that the 'fertilization does not consist in a union of cells that differ genotypically, nor do the cells have to differ phenotypically. It is not a question of + and − cells as in some Basidiomycetes. (It is a case of indiscriminate combination of any two cells.) . . . . One might feel inclined to claim that these Saccharomycetes show, among other things, that sex is not a prerequisite of fertilization. In the present instance, the fertilization plays a part in the developmental cycle without any demonstrable sex-difference of the cells'.

Side by side, I think, it would be useful to consider the remarks of some workers in connection with sex-determination

in seed-plants. For instance, Schaffner (56) states that protoplasmic structures have hereditary factors, although all normal Mendelian heredity must have its factors in the chromosome alone. Sexuality is a general potentiality and the balance may swing to maleness or femaleness through the influence of environment or a physiologic state which is brought about through a physiologic gradient in the regular ontogeny. He (57) maintains that if there is a difference in the chromosomes, it is a result of sex rather than a determiner of it. He points to sex-reversals, in which a male plant changes to female or *vice versa*, as conclusive evidence that sex is not determined by genes or chromosomes. Riddle (49) is of the opinion that sex-chromosomes or genes probably normally determine sex through the controlling metabolic rate, that the metabolic differences between male and female gametes can override the normally controlling influence of the chromosomes, that intersexes and hermaphrodites can arise from chromosomal or genic causes, but can also arise from a metabolic cause while chromosomes and genes are normal, and that the metabolic distinction found cannot be interpreted as a secondary sex-character. Bressman (13) has given an excellent summary of the literature on sex in seed-plants from which it is evident that there are many different opinions with regard to what determines sex. He remarks (13, p. 338) that undoubtedly the germ-plasm has much to do with the determination, but it does not probably decide everything regarding this character. His results show that sex reversals from male to female are fairly common in the cultivated species of hops, *Humulus lupulus*.

This leads to the theory of potential bisexuality which seems to hold ground in fungi (especially Hymenomycetes); of course, in the higher fungi there is no sexual apparatus. In *La Cellule* (pp. 258–259) in 1934, I discussed all the prevalent theories of sex in fungi which have emerged one after another—the theory of multiple sexes, of sexual mutation, of saltation under cultural condition, of nutritive heterothallism, of relative sexuality and potential bisexuality. Of these the theory of potential bisexuality seems to cover most of the facts in various groups of fungi. This theory was first put forward by Ames (1) in 1932. According to him the strains from uninucleate ascospores of *Pleurage anserina* are not heterothallic strains, male and female respectively, but are hermaphroditic self-sterile strains, requiring cross-fertilization by compatible opposites for the production of mature fruit-bodies (perithecia). Gwynne-Vaughan (34) also held in the case of *Ascobolus magnificus* in 1932 that its thallus is heterothallic but monœcious, all thalli being capable of bearing both male and female organs which are never self-fertile but cross-fertile—a view somewhat akin to Ames' idea of potential bisexuality.

Late Hans Kniep (41) from 1915 onwards and Mlle. Bensaude (3) in 1918 described the union of two mycelia of + and − strains as a necessary preliminary to the formation of sporophore in heterothallic species of Hymenomycetes. In such cases plasmogamy is usually separated from karyogamy in the basidium by several successive divisions of conjugate nuclei through clamp-connections. This is held as indicating a 'degeneration of the sexual process' and as the principal point of distinction from the type of sexual fusion in green plants where there is *simultaneous* fusion of protoplasm and nuclei of two conjugating gametes. But a closer reflection would lessen this difference; no doubt in the higher plants we have fusion of the two nuclei with the formation of the zygote and the initiation of the diplophase but not the fusion of two sets of chromosomes (male and female) which simply lie together in the fusion-nucleus; the actual fusion of chromosomes is delayed in higher plants by almost the same long steps till the prophase of the reduction-division or meiosis in connection with microsporogenesis or megasporogenesis. In the *Hymenomycetes*, on the other hand, the fusion of two nuclei in the basidium is almost at once followed by the fusion of their chromosomes in connection with meiosis. Thus, the only difference is that in the *Hymenomycetes* the two conjugate nuclei from two different strains (plus and minus) are not in actual contact with each other in the form of one fusion-nucleus as in the higher plants, though they lie very close in each cell of the hyphæ.

(*c*) *The enzyme action of some local Polypores.*—I have just now completed some work on enzymes in some of our local *Polypores* (*Polyporus ostreiformis*, *Polystictus hirsutus*, *Polystictus sanguineus*, *Daedalea flavida*, *Trametes lactinea* and others). In each case we have determined the more important enzymes, both intracellular and extracellular, in artificial culture in one particular liquid medium (2% malt-extract of pH 6·8) at three different stages of the species, viz. (1) young hyphal condition (purely vegetative mycelium), (2) old hyphal state (mycelium about to fruit), and (3) fruiting condition (actual fruits formed with adhering old mycelia); side by side we have compared the enzymes found in fresh sporophores formed in nature during the rains on prostrate logs, etc. The enzymes of the following groups were found: (*a*) carbohydrate-splitting, (*b*) proteolytic, (*c*) lipolytic, and (*d*) oxidizing enzymes. It is well-known that secretion of enzymes varies qualitatively and quantitatively according to the nature of the medium of the fungus. Having used malt-extract medium in all cases we got the predominance of carbohydrate-splitting enzymes. From the results tabulated it appears that in each case there is a marked decline in the activity of enzymes as the fungus passes from the purely vegetative state to the fruiting condition, that in the fruits formed

in nature the activity becomes still less (but in the case of catalase slight increase of activity in the fruiting stage in artificial cultures has been noticed) and that extracellular enzymes are much more active than intracellular ones. Of course, the quality and quantity of enzymes vary with each species, for instance, the diastatic activity of *Polyporus ostreiformis* is about five times as great as that of *Polystictus hirsutus* while the corresponding activity of maltase is about twice as great. In connection with enzymes, especially in the case of parasitic species, we should also consider the other side, namely that enzymes may sometimes be prevented from working by forces exerted by the living host-cells—a type of chemical resistance offered by the plant, as pointed out by Brown (16); in such cases there is no attack as the cell-walls of the plant cannot be dissolved by the enzymes. Corner (23) has shown that 'on inappropriate host the early stages of penetration are the same as on the proper host, i.e. the cuticle is pierced mechanically. The penetration-process, however, usually develops no further in the inappropriate host and is probably killed by toxic substances in the "host" cell'. Herein lies the importance of the knowledge of the chemistry of the cellulose, hemicellulose, pectin, and similar substances.

MEDICINAL PROPERTIES AND OTHER USES OF POLYPORACEÆ.

Some of the ear-shaped *Polypores* (especially *Fomes pectinatus* called in vernacular 'Kanchata', having resemblance to human ear or 'Kan') are used in crude form in various parts (Khulna district in particular of Bengal) amongst villagers to cure the weeping eczemas of the human ear. They usually burn the fruit-bodies and externally apply their ash. The chemical analysis of the ash of *Fomes pectinatus* kindly carried out by my friend, Mr. K. C. Roy, M.A., late Prof. of Chemistry, Presidency College, Calcutta, shows among others the following constituents :—

Silica, sand, etc.	31·7
Cl	·5
SO_4	2·3
K_2O	14·3
Fe_2O_3	22·5
P_2O_5	18·8
CaO	4·7

Polyporus anthelminticus collected from Bamboo-roots in the 24-Perganas in Bengal in September 1921, is used in Burmah as an anthelmintic (65, p. 258). The substance of *Polypores* (like *Ganoderma lucidus*, *G. applanatus*, etc.) may be used as strops for razors, as covers for boxes, etc. (21, p. 103). It is suggested (59) that woody shelf-fungi (*Fomes fomentarisus*,

etc.) may be used as a substitute for cork and kindling wood. In South Australia (20) the substance of the thick white fruit-body of *Trametes lactinea* is used as pith for mounting delicate insects, flies, and mosquitoes for entomological collections. Hymenial surfaces of *Hexagonia apiaria*, *Daedalea flavida*, *Lenzites alutaceous*, etc. may be used as a brush for polishing the rough surfaces of wood.

Ladies and Gentlemen, the aim of science is to extend the bounds of knowledge and reduce it to order. The sense of the unknown haunts the scientist; the intoxication of adventure and discovery is upon him. And while the true scientist *always* has to deal with the observable in life, he is *continually* inspired by what may be called 'the inner vision' of the yet unobserved possible whole which an intensive study of particulars bestows upon him. Of that 'inner vision' and that spirit of adventure is born a feeling of supreme joy. 'The joy of discovery', says Shear (58), 'and the intellectual pleasure to be derived from the contemplation and appreciation of the wonderful variety of forms, their complexity of structures and the mysteries involved in their origin and evolution, their life-histories and relationships, and the joy from the discovery of unknown facts and forms—these are some of the richest rewards for the student. Mycology may bring something much more satisfying and valuable than money or glory'. Again, be it remembered that this joy is never merely personal or selfish, for discovery dawns upon the scientist in rare moments of self-effacement and disillusionment. The man who dedicates his life to the search for truths in nature has the spirit of God in him. The laws of nature can be approached only by such spirit, the whole universe can be brought to order out of chaos by such laws.

Lastly, Ladies and Gentlemen, as I make my exit, let me bid formal adieu to you all and make room for my learned successor, who, according to our custom, has been already elected to this office of trust and responsibility.

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Section of Botany.

Abstracts.

ALGÆ.

1. Algal vegetation in relation to pisciculture.

K. BISWAS, Calcutta.

Scientific investigations are apt to be interpreted in terms of exchange by a section of people. The author has frequently been challenged regarding the uses of his investigation into what may be called the slime world. Various economical aspects of the study of algæ have been touched upon by Prof. M. O. P. Iyenger and Dr. S. L. Ghose in their presidential addresses before the Botany Section in 1928 and 1933. The author has therefore confined himself, for the present, to the most important economic aspect of algological investigation, namely relation of algæ to the cultivation of fishes. Fishes form an important item of human food; they in their turn live on various similar animals. These animals again in their turn live on algæ supplying them either food or shelter. The author has discussed in this paper some of the characteristic features of such species of algæ.

2. A note on a collection of slime algæ from the hot springs of the higher Himalayas.

K. BISWAS, Calcutta.

Mrs. H. P. V. Townend during her tour in May to June, 1935, in northern Sikkim collected two tubes of algæ from two hot springs at an elevation of 12,000 ft. to 15,000 ft. A characteristic green layer of Spirogyra sp. was observed forming a deep green slimy spreading cushion on the rocky bed of the hot springs. The other species formed a violet bed composed of a pure association of a form of *Oscillatoria*, cf. *terebriformis* (Ag.) Gom.

Another bottle of slimy mass was collected by Mr. J. B. Auden of the Geological Survey of India from a hot spring in the Kumaon Hills of the Western Himalayas in December, 1934. His specimens are composed of an *Oscillatoria* sp., *Phormidium* sp. and three species of diatoms—the most common of which (often found imbedded in the slimy mass of Phormidium and Nostoc) is a form of *Fragilaria mutabilis*.

3. Observations on a species of *Rhizoclonium* under culture conditions.

S. L. GHOSE, Lahore.

The species is very common in Lahore during most part of the year; it has not been identified definitely so far.

Plants were kept in a well-lighted place for more than a year in glass-troughs, full of tap-water, which was continuously aerated. Rhizoidal branches were seen to be formed in greater abundance than in normal conditions and were of much greater length.

Cultures were also made in petri dishes and in drops of water on a slide, which were kept in moist conditions. Here also rhizoids were formed more abundantly.

The formation, discharge and germination of zoospores has been studied.

A cell with a number of zoospores was hermetically sealed in a drop of water on the slide. In about a week's time the zoospores developed thin but clearly defined walls round themselves, and resembled aplanospores. These, however, have not been induced to germinate so far.

4. Three new myxophyceæ from Ceylon.

Y. BHARADWAJA, Benares.

The paper describes three new myxophyceous algæ, i.e. *Calothrix ramosa*, *Fischerella anomala* and its variety *fastigiata*. These plants are from the same Ceylon collection of Prof. F. E. Fritsch, F.R.S., from which the writer has already described a number of new forms.

5. On a form of *Pearsoniella* Fritsch et Rich from Benares.

Y. BHARADWAJA, Benares.

The paper describes a new form of the rare genus *Pearsoniella* Fritsch et Rich, and discusses its systematic position.

6. Seven new Chrysophyceae from the south-east coast of England.

P. ANAND, Lahore.

1. *Glœochrysis maritima* sp. nov. This species differs from *G. pyrenigera* Pascher in its marine habitat, in the small size of the cells, in the presence of two greenish-yellow chromatophores without pyrenoids and in the absence of contractile vacuoles and stigma.

2. *Glœochrysis litoralis* sp. nov. This species differs from *G. maritima* in the texture and colour of the stratum, in the ill-defined stratification of the envelops, in the shape of the cells and the colour of the chromatophores.

3. *Chrysotila stipitata* Gen. et sp. nov. This alga is chiefly characterised by its dendroid habit, the pear-shaped or oval cells being borne singly at the ends of simple or branched hyaline stalks, which consist of successive cupshaped strata. These stalks arise by periodic contraction of the protoplast in the upward direction which is followed each time by the secretion of a membrane. The part of the parent-cell left empty and intervening between the basal part of its wall and the base of the new cell appears as a cup. As this process of rejuvenation takes place repeatedly the original protoplast becomes carried up on a stalk of increasing length in which the successive membrenes appear as series of curved speta. In the method of stalk formation *C. stipitata* resembles Kuckuck's *Prasinocladus*, as described in detail by Lambert, where the stalks are likewise made up of compartments due to repeated rejuvenation of the protoplast. In *C. stipitata*, however, the protoplast never slips out entirely from the parent cell, so that the segments of the stalks are much shorter.

The dendroid types of colony hitherto known among Chrysophyceæ are represented by forms like Paschers *Chrysodendron*, in which flagellated cells, which may readily become detached, are seated singly at the end of a system of delicate forked stalks. So far, however, no dendroid types have been described parallel to forms like Kuckuck's *Prasinocladus* or Borzi's *Hormotila* among the Chlorophyceæ. *Chrysotila stipitata* fills this gap, resembling them in habit and the former in the manner of formation of the colony.

4. *Chrysotila lamellosa* sp. nov. The species is specially characterised by the rounded shape of the cells which have only a delicate wall, but are surrounded by a thick concentrically lemellated envelope.

5. *Apistonema Carteri* sp. nov. This species of *Apistonema* is distinguished by its marine habitat. It differs from A. *commutatum* Pascher in the size of the cells, in the presence of two chromatophores and in the development of long branched filaments. From A. *pyrenigerum* Pascher it differs in the size and often considerable length of the cells, the mode of branching, the absence of pyrenoids and contractile vacuoles and the presence of intercellular strata resulting from the deposition and gelatinisation of successive membranes.

6. *Thallochrysis litoralis* sp. nov. This species differs from *T. Pascheri* Conrad in the marine habitat, in the production of longer filaments consisting in part of two rows of cells and in the presence of two chromatophores.

7. *Chrysonema litoralis* Gen. et sp. nov. The unattached filaments are erect and bear short branches which arises from the upper end of the parent cell and usually consist of only one or two cells. The cells are all cylindrical, 8-12μ broad and 2-3 times as long. The genus is essentially characterised by its unattached habit, by the absence of differentiation among the cells and by the possession of a single chromatophore. In the first character it resembles Geitler's *Chrysoclonium*, but differs from it in the longer cylindrical cells, the different method of branching and especially in the possession of a single chromatophore. There is a certain resemblance to the filamentous stages of *Apistonema Carteri*, but the two forms occur in quite different habitat and the constituent cells of *Chrysonema* never separate; moreover those of the former usually contain two chromatophores and have a cellulose wall.

7. On some new marine Myxophyceæ.

P. ANAND, Lahore.

1. *Chroococcus calcicola* sp. nov.—penetrating into the chalk to a depth of about one millimetre; differs from *C. lithophilus* Ercegovic, the only other species with the same habit, in the smaller angular cells, with pale-blue contents, the invariably hyaline sheaths, and the occurrence, of cells in groups of 3 or 4.

2. *Xenococcus violacea* sp. nov. This species shows certain resemblances to *X. pyriformis* Setch. and Gard. and *X. Gilkeyæ* Setch. and Gard. It differs from the former in the shape of the cells, the purple colour of the protoplast, the formation of parenchymatous discs, the size of the spores and the occasional presence of a sterile basal portion in the sporangium. It resembles *X. Gilkeyæ* in the structure of the sporangium, but differs from it in the size of the cells and spores, in the colour of the contents, in the presence of a distinct cell-wall and in the formation of large colonies.

3. *Dermocarpa Enteromorphæ* sp. nov. This species stands nearest to *D. spæroidea* Setch and Gard., but differs from it in the large cells, in the thick stratified wall and the bigger spores.

4. *Calothrix litoralis* sp. nov. This species is specially characterised by the elongate flexuous threads, which do not taper into a hair, have basal heterocysts and a firm moderately thick, non-ocreate sheath. It lacks the symplocoid habit of *C. pulvinata* from which it differs in the thin non-ocreate sheaths, the blue-green colour of the trichomes, the serial basal heterocysts, and the occasional occurrence of intercalary heterocysts.

5. *Calothrix pulvinata* Ag. var. *prostrata* var. nov. The variety is characterised by its prostrate endophytic habit, the highly flexuous and elongate threads, the thick sheath and the basal seriate heterocysts. In some of the older filaments the sheaths show transverse annulation mainly at the base.

6. *Plectnema litoralis* sp. nov. This species is markedly characterised by the thick orange-coloured sheath, the profuse branching, the slight tapering of the trichome and the short branches forming hormogones. It differs from *P. calotrichoides* in the absence of markedly tapering filaments and the large size of the cells.

7. *Phormidium foveolarum* (Mont. Gom.) forma *moniliformis* f. nov.—characterised by the short, strongly coiled trichomes and the small size of the cells.

8. *P. molle* Gom. forma *elongata* f. nov. Cells elongate, 1.8-2μ broad, 2-6.5μ long.

forma *minor* f. nov. Filaments short, torulose, usually bent, sheaths not visible, cells 1.5-2.2μ broad, 1.7-3μ long, with pale blue contents.

9. *P. submembranaceum* (Ard. and Straff.) Gom. var. *minor* var. nov. Characterised by the absence of marked tapering at the ends of the trichomes and by the small size and isodiametric shape of the cells.

10. *Lyngbya gracilis* Raben. var. *maritima* var. nov. This variety differs from the type in the glistening deep-blue stratum, the firm sheath, the small cells which are as long as broad, and the absence of any thickening on the apical cell.

11. *Schizothrix Fritschii* sp. nov. The species is characterised by its epiphytic habit, by the thin hyaline sheaths, and the narrow pale-brown trichomes. It differs from *S. Cresswellii* in habit and in the narrow width of the tufts and the filaments.

8. An Ecological and Taxonomic Study of the Algæ of the British Chalk-cliffs.

P. ANAND, Lahore.

No previous ecological and taxonomic account of the algal flora of the British chalk-cliffs, and particularly of that of the spray zone has been published and the present investigation thus deals with an hitherto unexplored field.

The algal vegetation along the base of the cliffs is grouped into a number of distinct horizontal bands which extend for long distances and are interrupted only by the caves, artificial embankments, etc. Four definite belts can be distinguished from below upwards, viz.

1. The *Fucus*-belt.
2. The *Enteromorpha*-belt.
3. The *Chrysophyceæ*-belt.
4. The *Endoderma*-belt.

Each belt displays a distinctive colour determined by that of the dominant species of alga present. The *Fucus*-belt is in great part submerged at high tide, while the others are only reached by the spray.

The chief factors influencing the distribution of the algæ on the face of the cliff are the water-relations, the salt-concentration and the temperature. In the tunnels hollowed out by the waves, currents and the shade from direct sunlight play the principal rôle. Inside the caves the distribution in belts becomes vertical rather than horizontal, being determined principally by the light-intensity at different distances from the opening. The various factors concerned have been investigated experimentally both on the spot and in the laboratory.

The algal vegetation in the various belts can be grouped into a number of communities whose distribution is related to their position with respect to high tide-level, to the degree of illumination and to the nature of the substratum. In several cases, too, the development of a community is seasonal. Most of the communities distinctive of the *Chrysophyceæ* and *Endoderma*-belts are new for the algal vegetation of the litoral region. Their absence on the stone and concrete embankments indicates a preference on their part for the chalk-substratum.

The total number of species observed is 151, a number of which are new records for the British coast. They include two new genera (*Chrysotila, Chrysonema*), 13 new species (*Gloeochrysis maritima, G. litoralis, Chrysotila stipitata, C. lamellosa, Apistonema Carteri, Thallochrysis litoralis, Chrysonema litoralis, Chroococcus calcicola, Xenococcus violacea, Dermocarpa Enteromorphæ, Calothrix litoralis, Plectnema litoralis* and *Schizothrix Fritschii*) and 9 new varieties and forms (*Xenococcus Gilkeyæ* forma, *X. Schousboei* forma *Calothrix pulvinata* var. prostrata, *Phormidium foveolarum* f. *moniliformis, P. foveolarum* f. *minor, P. molle* f. *elongata, P. monile* forma, *P. submembranceum* var. *minor, Lyngbya gracilis* var. *maritima*).

FUNGI.

DISCUSSION ON 'SALTATION IN ARTIFICIAL CULTURES OF FUNGI'.

S. N. Das Gupta, Lucknow, opened the discussion.

S. N. Das Gupta.—It has been shown by various investigators that fungi of monohyphal and monosporal origin which have been breeding true for many generations may suddenly give rise to new strains from certain parts of the culture. The phenomenon of sudden and spontaneous production of a new form, from a genetically pure one is termed mutation in higher plants. The term mutation, however, has a definite genetical significance; but no such significance can be adduced to the variations observed in fungi. Hence the term saltation has been introduced to describe the phenomenon in fungi which is comparable to mutation in higher plants without any reference to the genetical changes involved in the process. The term is not universally adopted. Both saltation and mutation are extensively used by mycologists, the choice resting with the authors.

Saltation in a fungal mycelium may occur in the form of a sector or it may be masked. The former is more common; the latter condition has been obtained in a strain of *Fusarium* (Brown 1926) and in *Diaporthe perniciosa* (Horne and Das Gupta 1929) where the presence of the saltants is only apparent when portions of myceliumare separately cultured.

Various types of saltation can be distinguished.

1. Orthogenetic.—Where saltations themselves in their turn saltate to produce new strains, so that there is a series of strains, one arising out of another in one genealogical line. (Stevens 1922, Christensen 1929, Mitter 1929).
2. Cyclic.—Where a particular strain gives rise to a saltant and the saltant later produces back the parent form. The parent and the saltant must never lose their identity and remain distinct from each other. (Horne and Das Gupta 1929, Brett 1931, Wiltshire 1932).
3. Saltation into complementary strains.—In which strains possessing complementary characters are produced. For example, CA_2 and CA_4, two infertile saltants of *Cytosporina ludibunda*, are complementary, with respect to pycindia formation (Das Gupta 1933).
4. Saltation with age.—Invariably occuring at a definite age of the mycelium. (Horne and Das Gupta 1929)
5. Ever-saltating strains.—Forms which saltate in every cultural generation. (Horne and Das Gupta 1929).

Saltation may involve (i) morphological character, (ii) physiological character, and (iii) pathogenicity of fungus. The changes shown are extensive and involve not only one but many of the specific and sometimes generic characters. The importance of saltation in the taxonomy of

fungi is thus obvious. The change in pathogenicity due to saltation is quite common. The saltants are usually found to be less parasitic than the parent (Harvey 1929). A number of cases has, however, been observed where the saltants were relatively more virulent than the parent strain (Christensen 1925, Das Gupta 1933). This indicates that saltation from non-pathogenic or less pathogenic strain to highly pathogenic ones may occur in nature as well. The weaker parasitic power of a saltant in comparison with the parent is no conclusive proof of its harmlessness in nature since a parasite is weak only with regard to a particular host, if the host is different the rôle may be reversed. This is found in certain parent and saltant strains of *Cytosporina ludidunda* where CA_4 and MK attacked Bramley's seedlings apples less virulently and Worcester pearmain apples more virulently than the parent (Das Gupta 1933).

Saltation can be induced by almost all the factors which have effect on the growth of a fungus. For example (i) chemicals, (ii) temperature (Barnes 1928, 1930, 1935), (iii) ultra-violet radiation (Stevens 1928, Dickson 1932), (iv) X-radiation (Dickson 1932, 1933), (v) radium radiation (Sibilia 1934). The saltants produced are independent of the nature of inducing agent employed, since identical saltants have been obtained by means of ultra-violet and X-radiation (Dickson 1932).

I have used the term reversion to denote such cases where a saltant completely loses its identity during culture and changes to the original parent type. Reversion is more or less common (Chaudhuri 1931) and is of great significance since it implies that whatever genetical changes might lead to the occurrence of saltation the reverse process must also occur during reversion.

In spite of the large amount of work done on saltation our knowledge regarding the problem is meagre. Many important questions still remain unsolved, viz.—

1. The specific purity of fungal strains. The first condition that must be satisfied to prove the occurrence of saltation is that the strain concerned must be genetically pure. In mycological work the accepted criteria of the specific purity of a strain is that the strain should have its origin from a single spore or from a small fragment of a hypha and that it should breed true to type. Monohyphal or monosporous origin of a strain is, strictly speaking, no test or purity, since the genetic constitution of either may not be pure. It has been proved by the author (Das Gupta 1934) that even a small fragment of a hyphal tip from an apparently pure culture may have two distinct characters associated together. All cultures should, therefore, be subjected to searching examination before being finally passed as pure.

2. Probable causes of appearance of new strains.

(*a*) *Segregations from heterozygous or hybrid strains* Heterozygosis is common in fungi and since the past history of almost all fungi remains unknown, it is possible that some saltations recorded in mycological literatures are mere cases of segregation. It would, however, be unwise to dispose of all the saltations as segregation from hybrid strains.

(*b*) *Hybridisation.* The experimental evidences are conflicting. Dickinson's method, which consisted in crossing two distinct strains and isolating the fusion hyphæ and growing them separately, gave negative results (Dickinson 1932). Further experiments on this line are likely to produce important results.

(*c*) *Change in nucleus, chromosome* or *gene character.* Solution of this problem is difficult since most of the fungi do not lend themselves to genetical experiments as higher plants do ; the minuteness of the nuclei, their multiplicity, etc. are all against it. It is not improbable, however, that some of the saltations are due to real change in chromosome and other characters. Much light will be thrown on the problem if fungi with larger nuclei are induced to saltate and the parent and the saltant strains genetically studied.

Saltation in Fusarium and the species-concept.

J. H. MITTER, Allahabad.—During a study of some species of *Fusarium* included in the section *Discolor* it was found that in several instances the differences existing between the saltants derived from a given parent were greater than those which separate one variety from another of the same species, and even one species from another. Even the criteria used for the sectional grouping of the species, e.g., spore shape, substratal colouring, chlamydospores and their disposition, and formation of microconidia, are found to be entirely unsatisfactory. Thus, saltant Cj 3 of *F. culmorum* belonging to the section *Discolor* produced spores characteristic of the section *Elegans*. Such a behaviour of the genus has greatly added to the confusion already created by the presence of a large number of species.

There seems to be no truth in the baseless assertion that saltants are mostly due to *artificial* cultural processes. Sleeth has obtained evidence to show that they are also quite frequent in the soil.

It has been held that saltation is mainly a nutritive phenomenon, and that almost all the saltants could be reverted back by proper selection of the medium, especially by the use of a starchy medium. Reversions no doubt have been observed, but in many cases a saltant. which has been cultivated for many generations on a starchy medium, has remained true. Whether or not they revert back, the saltants show characters which transgress the limits at present laid down for the numorous species of *Fusarium*.

The behaviour of saltants has been thought to seriously interfere with the taxonomy of the group, but most of the difficulties will be removed if we consider them to be nothing but manifestations of the variability of the organisms, and if we agree to discard our preconceived notions regarding a fixed 'type' species of the genus *Fusarium*. This point of view has been ably expressed by Leonian according to whom a given species is not an absolute entity, permanently and definitely established in the scheme of things, but a fluctuating group of organisms more or less loosely bound in a flexible orbit. The study of saltants has repeatedly shown that we have to enlarge considerably our conception of a species in the genus *Fusarium*.

H. CHAUDHURI, Lahore.—True mutation is very raro in fungi, but changes to new forms in culture in the laboratory are very common. These sudden changes, appearing in the form of sectors in petri dish cultures, have been known as saltations. Saltants have in many cases been described as growing true as new forms, but it has been found that they grow as true new forms only in a particular medium or media; for all or most of these so-called saltants some medium or other could always be found, by growing in which the saltant could be reverted to its original form. Very few saltants are formed in nature. They mostly appear in laboratory cultures, and it has been found that fungi have a greater tendency to saltate in synthetic solid media (e.g., Richards') and that in starch media very few saltants are formed; also that saltants formed in a synthetic medium could be made to revert to their original forms by either cultivating them in starch media for a few generations or by growing them on their original hosts. Saltation in fungi is considered to be a nutritive phenomenon unless it be a raro case of true mutation.

9. Some studies on the leaf spot disease of wheat caused by *Septoria tritici* Desm.

J. C. LUTHRA, ABDUS SATTAR, *and* ABDUL GHANI, Lyallpur (Punjab).

This leaf spot disease, which has been found to be very common in many districts of the Punjab, has been found to be caused by a fungus

known as *Septoria tritici* Desm. A detailed morphological description has been given, and the influence of the various environmental factors such as rainfall, temperature, and wind on the incidence and development of the disease has been studied. The infection has also been recorded for the first time as attacking the glumes and awns of the wheat plant besides its leaves ; this indicates that the fungus might attack the grain also through the glumes and the affected grain might carry the fungus.

Methods of perpetuation of the disease on leaves of wheat-straw and its possible control measures have been described and suggested. Of the three species of wheat found in the Punjab, *Durum* types have been found to be immune.

10. On the cultural behaviour of a species of *Rosellinia.*

S. N. Das Gupta, Lucknow.

A cultural study in connection with the development of perithecium of a species of Rosellinia obtained from apple orchard air of the East Malling Experimental Station (England) has been made. It has been found that profuse production of perithecium occurs in the plain agar medium but in Brown's synthetic medium the fungus fails to produce any perithecium.

With a view to ascertaining the inhibitory influence of the chemical or chemicals present in Brown's synthetic medium on the production of perithecium in this Rosellinia, a series of media was prepared by adding K_3PO_4, $MgSO_4$, asparagin, glucose, starch, etc. separately to the plain agar and in various combinations in the same proportion as in the standard Brown's medium, and the media were inoculated with Rosellinia.

It was found that agar containing only K_3PO_4 or only asparagin when inoculated with the fungus does not inhibit the formation of perithecium, neither does the inhibition occur in the medium such as agar $+MgSO_4$ or agar$+MgSO_4+K_3PO_4$ or agar$+MgSO_4+$asparagin. But when K_3PO_4 and asparagin are both present in the medium (agar $+K_3PO_4+$asparagin) perithecium fails to develop. On addition of $MgSO_4$ to the last named medium, a tendency towards the formation of perithecium becomes apparent. This tendency disappears altogether on addition of glucose and starch, the rest of the constituents of Brown's medium.

11. Notes on the fungi of Lucknow. (i) On the perithecial stage of *Sphaerostilbe bambusae* Pat. on *Bambusa indica.*

R. S. Mathur, Lucknow.

Sphaerostilbe bambusae is commonly known in its conidial form as *Stilbum bambusae* Pat. et Gail, and during June and July, when the summer monsoon just breaks in the United Provinces of Agra and Oudh, thick forests of minute nail-shaped, orange-coloured, conidial fructifications appear on Bamboo culms.

The perithecial stage of this fungus, which was so far unknown, has been lately discovered at Lucknow and neighbouring places. The present paper deals with the morphology of this perfect stage of *Sphaerostilbe bambusae* in some detail. In the middle of September when these conidial stalks begin to shrivel up, minute pinkish or sometimes orange-coloured perithecia appear on thick stromata giving a woolly appearance. These are 200-300 μ in diameter. Asci are 50-60 μ $\times$6-8 μ broad; ascospores bicelled, hyaline, 14-15 $\times$ 4-5 μ.

12. Notes on the fungus flora of Lansdowne (Garhwal district, North-West Himalayas).

R. S. MATHUR, Lucknow.

During June and July, 1932, Professor B. Sahni made a collection of Fungi at Lansdowne. He very kindly placed the whole collection at the author's disposal. In all ten forms have been described, of which *Microthyrium cedrii*, *Scleroderma Sahnii*, and *Sirothecium visci* happen to be new species.

The presence of oogonia-like structures in *Dimerosporium Longloisii* E and E on the pinnæ of *Cycas revoluta* has been observed. Cultural study of the fungus is in progress to establish the connection of this stage in its life history.

A new name *Entyloma selaginallæ* has been suggested to the smut occurring on the two Indian species of *Selaginella*, namely *S. chrysorrhizos*, and *S. chrysocaulos*.

The smut was first observed by Mr. T. C. N. Singh on *S. chrysocaulos*, who suspected it to be an *Entylomas*, but did not come to any finality in its identification. Recently, however, Dr. P Maheshwari and Mr. V. Puri have noticed in this smut greater resemblances to *Melanotaenium* sp.

The writer, however, had the privilege of examining several Indian species of *Entyloma* at the Mycological Herbarium, Pusa, and is inclined to think it definitely to be an Entyloma sp., and to avoid further confusion about the identification of the fungus suggests the new name *Entyloma selaginellae*.

All the identifications were carried out by the writer with the kind help of the authorities of the Imperial Institute of Agriculture Research, Pusa, and much of the information collected by him there, was later on confirmed by Dr. E. J. Butler of the Imperial Mycological Institute, Kew, Surrey.

13. Indian water moulds.—Part II.

H. CHAUDHURI *and* S. SINGH, Lahore.

Some more new water moulds are described, and the behaviour in culture of some of the water moulds is described in detail.

14. A disease of the pomegranate trees in Lahore caused by *Phoma sp.*

DALIP SINGH, Lahore.

This disease was noticed in a pomegranate orchard in Shahdara, near Lahore. The symptoms of the disease have been described, and the life-history of the causal organism has been studied. Inoculation experiments have been done to prove its pathogenicity, and the cultural characteristics in various media have been given.

LICHEN.

15. On a rare lichen from Lansdowne.

R. S. MATHUR, Lucknow.

Among the many specimens which Prof. B. Sahni collected from Lansdowne in June and July of 1932, and placed at the writer's disposal, was also a tube containing a *Calicium* sp.

The specimen seemed for all purposes a Discomycete, but on closer examination revealed the presence of Pleurococcus cells inside the stalk. This confirmed its being a lichen, belonging to the primitive group of *Coniocarpineae* among the Ascolichens.

This primitive group of lichens, whose members are recorded in fair abundance from European localities on the community of oak-hazel woods, is still obscure in India.

Only *Tylophoron moderatum* of the family *Cypheliaceae* has been recorded by Mr. G. L. Chopra of Lahore, and a more thorough search may reveal the presence of some more new forms of these little known lichens in the Kumaon Hills.

This Indian species of *Calicium*, however, agrees in general characters with *C. quercinum* Pers., but the size of the asci and ascospores is nearly double. It also resembles *C. curtum* in the size of its ascospores, etc. The writer thinks it to be a new variety of *C. quercinum*.

BRYOPHYTES.

16. The present position of Indian hepaticology.

S. K. Pandé, Lucknow.

In this paper the author gives a critical review of the literature on Indian liverworts from the time of William Griffith (1835) to the present day. Certain important problems, such as the distribution of liverworts in the Western Himalayas, are also discussed.

ANGIOSPERMS. 1. MORPHOLOGY.

DISCUSSION ON 'STANDARDIZATION OF THE VERNACULAR NAMES OF INDIAN PLANTS'.

M. Sayeeduddin, Hyderabad (Deccan), opened the discussion.

M. Sayeeduddin.—The late Dr. Mukerji drew the attention of the Botany Section of the Indian Science Congress held at Bangalore in 1932, towards the standardization of the vernacular nomenclature of Indian medicinal plants. He restricted himself to a limited field, that is the nomenclature of the medicinal plants only. The object of this note is to point out the hopelessness in which the nomenclature of all our plants is, and to draw the attention of the members of the Botany Section of the Science Congress towards taking early steps to appoint a committee of experts consisting of systematic botanists, horticulturists, pharmacologists and linguists to endeavour to assign only one name to each plant by which alone it will be known throughout the length and breadth of India.

It was resolved in the section that Mr. Sayeeduddin should start compiling the vernacular names of Hyderabad (Deccan), and that each province should have a committee of its own to compile a list of local vernacular names.

17. Vegetation in and around the Lloyd Botanic Garden, Darjeeling.

K. Biswas, Calcutta.

The town of Darjeeling is what may be called the hill territory of British Sikkim. Situated at an elevation of about 6,000 to 8,000 ft., it represents a portion of 'the temperate zone of Sikkim'. The rainfall and climatic conditions are very favourable to the growth of

plants. Hence within the range of a small compass one meets with a rich collection of species characteristic of the Sikkim Himalayas. Although human interference has considerably checked the indigenous species from having their full play, yet the number of species and their quantity are sufficient to make an impression of some of the characteristic plants of the Eastern Himalayas. Rhodendrons, magnolias and primulas are the pride of these hills. The Lloyd Botanic Garden, Darjeeling, forms a store-house of some of the alpine plants which have been acclimatised. Within a small area of 45 acres of land attempts have been made to exhibit some of the foreign temperate species, also maintaining as far as possible the artistic style of landscape gardening. The rich stock of Conifers of this garden forms an important feature. Different types of vegetation will be illustrated.

18. Common plants of Northern Sikkim.

K. BISWAS *and* MRS. H. P. V. TOWNEND, Calcutta.

The collection of Sikkim plants dates as far back as 1837-1838, when Capt. R. B. Pemberton visited Bhutan; and his collection was subsequently reported by Dr. W. Griffith, of monumental fame. To this collection has been added in May, 1935, a collection of 2,500 plants by Mrs. Townend and Babu H. P. Naskor of the Calcutta Herbarium. The different successions of vegetation noticed may roughly be divided into three altitudinal zones. The first range of vegetation is of the deep valley of the Teesta at elevations varying from 2,150 ft. at Dikchu to 5,350 ft. at Chungthang, and is of the usual type of sub-tropical Eastern Himalayan species. The next range is from Chungthang to Thangu, 12,800 ft. The march through this part gives an impression of a typical garden of the most interesting temperate flowers of the Eastern Himalayas. There is no marked change in the composition of the herbaceous association till a few miles short of Lachen is reached at a height of 8,800 feet. The real rhododendron and primula country, however, is reached some miles beyond Lachen. Here lovely tangerine coloured *Rhododendron Roylii* are plentiful. This species is gradually replaced by the different shades of mauve and sulphur coloured rhododendrons higher up the wide valley extending to Thangu. In the open ground in between, groups of primulas with their different shades of colour of flowers formed artistic patches here and there. The sapphire blue *Meconopsis simplicifolia*, and the well-known medicinal plant *Podophyllum emoldi* adorned the glades between the trees and bushes. Spreading over the rocks at the edge of the river, a gay purplish pink tamarisk forms a marvellous background to the landscape. The highest range of vegetation visited was between 13,000 to 18,000 ft. On this highland little but compact flat cushions of dwarf primulas and meconopsis predominate. The alpine meadows beyond Donky La above an elevation of 15,000 ft., near Mome Samdong, are covered with such characteristic plants as *Mandragora caulescens*, ranunculas, saxifragas, primulas, meconopsis, gentians, and clumps of taller white *Cassipape selaginoides*, and the remarkable species of *Rhododendron setosum* and *R. anthopogon* spreading over a considerable area.

19. A preliminary survey of the vegetation of Mulug, Warangal district, Hyderabad, Deccan.

M. SAYEEDUDDIN *and* M. A. SALAM, Hyderabad, Deccan.

The flora of H.E.H. The Nizam's Dominions is being worked out district by district. At present attention is directed towards the vegetation of Mulug—a talukha of Warangal district. It is a Government

Forest Reserve and presents the full luxuriance of tropical vegetation. For the major part the soil is 'regar' (black cotton soil), with patches of red soil for short distances. In the paper, details of plants under cultivation and those of the wild or naturalized plants are given.

Altogether seventy plants belonging to thirty-eight different families are recorded. There is yet a lot of collected material which is to be identified.

20. Some genetical observation on *Hibiscus rosa-sinensis*, Linn.

P. N. Mazumdar, Dacca.

The setting of seeds in *Hibiscus rosa-sinensis*, Linn, has been attracting the notice of botanists for some time past. Prof. G. P. Mazumdar observed it for the first time in 1932, and since then he has been observing it every year. Prof. Kundu reported its occurrence from Rajshahi in 1934, Misra in 1931 reported the perfectly normal development of embryosac with normal egg-apparatus, though Prof. Tewary and Salim Ali reported it to be otherwise in 1933.

In the present paper the author not only collected the perfectly developed seeds, but grew as many as 19 well-developed plants in generation$_2$ which are producing a large number of flowers. Parental characters have been combined or split up in this generation both in vegetative and reproductive organs. Entirely new characters have also been observed. The author is trying to collect seeds from generation$_2$ to get generation$_3$.

21. A preliminary account of the vegetation of the Garo Hills.

T. D. Srinivasan, Calcutta.

This paper presents a short account of the vegetation of a portion of the Garo Hills round about and above Tura, which is situated on a small plateau near the base of the Tura hill, which forms the main range of the Garo hills.

The Garo hills, forming the western extremity of the Khasia and Jainta chain, consist mainly of low hills running roughly north to south, with the two principal ranges, the Tura and Arbela, running in a south-easterly direction.

The zonal variation in the vegetation on the sides of the hills leading up to Tura and above up to about 4,000 ft. is dealt with. The general nature of the vegetation may be said to be a mixture of the open deciduous forest at lower altitude, and evergreen types at higher elevations and in the valleys. The Garo hills, though forming the western part of the Khasi range (where the rainfall is comparatively high), do not receive as much rainfall, being outside the effective zone where both the monsoons meet. This has an influence on the nature of the vegetation.

A systematic enumeration of the plants collected, with notes and observations, completes the paper.

22. Extra-floral nectaries in *Tecoma capensis*.

P. Parija *and* K. Samal, Cuttack.

The distribution, structure and development of the extra-floral nectaries and glandular hairs in *Tecoma capensis* have been studied. Their structure agrees in all essentials with those in other members of Bignoniaceae as studied by various authors. In distribution, however, *Tecoma capensis* differs from *Spathodia* in the fact that nectaries are found in its petiole, while they are absent from the ovary.

23. Observations on the structure of the seed of *Ipomaea pescaprae*, D. (I. bilob Forst.), and its germination.

N. K. TEWARY, Benares.

The seeds were collected last year at Puri. They could be successfully germinated last July at Benares. The seeds possess a very resistant testa, which is permeable to water with very great difficulty. The seeds, therefore, ordinarily germinate very slowly and with great difficulty. The germination can be hastened by removing a part of the testa artificially. These observations give an account of the structure of the seed and the process of germination.

24. On the proliferations of rose and other flowers.

B. C. KUNDU, Rajshahi.

The modified nature of the flower has often been explained by the occasional proliferations on the flowers of rose. The writer has collected two roses with one and two proliferations respectively on them. In the first case the main axis has continued to grow and develop another flower when the first one has withered. In the second case the two proliferations (two flowers) have taken their origin in the axial region of the floral leaves.

On a withered capitulum of *Calendula* sp. the writer has observed as many as four proliferous capitulums. All of them have developed directly from the flat rachis.

25. Monstrosity due to regeneration.

H. K. BHATTACHARYA, Mymensingh.

Furcræa gigantea produces innumerable flowers on a pole-like scape similar to the well-known plant *Agave cantala*. These flowers are ultimately converted into viviparous bulbils which produce small roots and leaves and falling to the ground grow into plants. These bulbils generally require six years for their maturity to produce flower-scape. Once the upper part of a fully developed flower-scape of this plant was severed, some monstrous bulbils were found to grow on the stock. They became very prominent on account of their unusual capacity for producing a flower-scape even in that early stage of their life. Both a bulbil and a flower-bud arose on their scapes, side by side, within the axil of every small bract. The bulbils were comparatively weak, while the flower-buds produced well developed flowers, but viviparous bulbils were not produced from them. The plastic material supplied by the mother plant is solely responsible for the early growth of the flower-scapes.

ANGIOSPERMS. 2. CYTOLOGY.

26. Significance of chromatic bodies in *Osmunda javanica*, Bl.

P. C. SARBADHIKARY, Colombo.

The view that chromosomes have a permanent individuality, which is maintained throughout from one cell generation to another, may be established by the presence of chromatic bodies in resting interkinetal nuclei of *Osmunda javanica* Bl. The chromatic bodies of the resting stage are identical with the chromosomes of the preceding telophase. The fine chromatic precipitate gradually recondenses to form chromatic

beads and these concentrate into fewer and fewer chromatic bodies as the more definite resting stage is approached. From the sequence of events and from comparative analogies it is considered that definite aggregations of chromatin which are visible in some resting nuclei are merely the expression of chromatic concentration.

27. The development of the endospermal haustoria in *Russelia juncea* Zucc.

C. V. Krishna Iyengar, Bangalore.

Massive integument and reduced nucellus are met with in this plant. Tapetum composed of small cells develops from the innermost layer of the integument and surrounds the tapering end of the embryosac. The two transverse divisions of the primary endospermal nucleus are followed by a wall-formation resulting in a row of three cells; of these the middle one gives rise to the endosperm later on. The cell towards the micropylar end by further divisions gives rise to four uninucleate simple and unbranched micropylar haustoria. The cell towards the chalaza by a longitudinal division gives rise to two simple and unbranched uninucleate haustoria, which later on fuse together resulting in a single binucleate chalazal haustorium. Development of the embryo does not reveal any peculiarity deserving mention.

28. On the embryosac and embryo-development of *Holoptelea integrifolia* Planch.

N. K. Tiwary, Benares.

This note records the author's observations on the development of the embryosac and embryo. In concluding, a few remarks are offered on the systematic position of the plant.

29. Studies on the life-history of *Platystemma violoides* Wall. Part I. Observations on the germination of *Platystemma violoides* Wall.

N. K. Tiwary, Benares.

Platystemma is a monotypic Himalayan genus of the Gesneriaceæ, whose life-history is completely unworked. This note records the author's observations on the seedlings of this plant, and offers interpretations of certain obscure but interesting points about its morphology.

30. Studies on the life-history of *Platystemma violoides* Wall. Part II. On the embryosac and embryo of *Platystemma violoides* Wall.

N. K. Tiwary, Benares.

This paper records the author's studies on the embryosac development and embryo in this species. It is shown that the development and structure of the embryosac, on the whole, conforms to that described for other plants of this family. Notice is taken of certain interesting points in the development of the embryo.

31. Comparative studies in the embryogeny of the Convolvulaceæ—II.

N. K. Tiwary *and* V. Sitaram Rao, Benares.

(*a*) The embryo development of *Evolvulus alsinoides* Linn.—

The development in this species is more or less normal, with a long suspensor at the end of which the embryo is differentiated. It is compared with the development of *E. nummularis* described by one of the authors last year, and attention is drawn to some important differences.

(*b*) The embryo development of *Ipomaea pes-tigridis* Linn.—

The peculiarity here consists in the development of a large micropylar haustorium, the suspensor itself being relatively very short.

(*c*) The embryo development of *Ipomœa hederacea* Jacq.—

In this species a large haustorial development is present. The haustorial growth is very long and pushes the embryonal end into the embryosac.

(*d*) The embryo development of *Merremia emarginata* Hallier f.—

In this species also the embryo development is initiated by the development of a micropylar haustorium. The suspensor is generally absent, its position being occupied by the haustorial mass of cells.

32. A contribution to the life-history of *Evolvulus nummularis.*

N. K. Tiwary *and* V. Sitaram Rao, Benares.

This study relates to the development of the male and the female gametophytes of the plant, and to fertilisation. There is a normal 8-nucleate embryosac developed from the chalazal megaspore of a linear tetrad. It is very long and narrow. The antipodals are small and short-lived. The egg produces a beak-like process prior to fertilisation. Microspores are formed by furrowing. In earlier stages the gemini are ring-shaped, usually with two knots. The haploid number is twelve.

33. Somatic cell-division in the root-tips of *Pinus Gerardiana.*

N. K. Tiwary *and* V. Sitaram Rao, Benares.

The resting nucleus is either spherical or elongated with a number of nucleoli. The reticulum is coarse and very irregular. In the prophase it gets broken up in certain regions, and simultaneously with this condensation and thickening of the chromatic material takes place. At the beginning of the metaphase a distinct longitudinal split is found in the chromosomes, which are numerous and long. The attachment of the spindle-fibres is in the middle of the chromosomes. Some of the chromosomes have got one or two constructions which do not coincide with the point of attachment of the spindle fibres. The spindle is bipolar.

34. A contribution to the morphology of *Antigonon leptopus* Hook. and Arn.

V. Sitaram Rao, Benares.

The number of primary archesporial cells is variable, ranging between 1 and 5. Only one pursues its further development.

A linear terrad is formed, and the innermost megaspore functions, developing into a normal 8-nucleate embryosac. Each synergid is capped by a filiform apparatus. The diploid chromosome number is 48. The mature pollen grain contains a tube-nucleus and a generative nucleus.

35. The embryosac of *Maerua arenaria* Forsk.

V. SITARAM RAO, Benares.

The primary archesporial is hypodermal. A parietal tissue is developed. A linear tetrad is formed, the innermost megaspore functioning. The synergids are long and narrow, and are capped by a filiform apparatus. The antipodals are large and occupy the lower half of the sac.

ANGIOSPERMS. 3. ANATOMY.

DISCUSSION ON 'THE IMPORTANCE OF ANATOMY IN TAXONOMY'.

P. MAHESWARI, Agra, opened the discussion.

DR. P. MAHESHWARI opened the discussion by first considering the methods whereby phylogenies are determined. Among these the study of fossils comes first, but from the exigencies of fossilisation it is apparent that the fossil record can never be complete and we have therefore to turn to other sources for much valuable information.

With the rise of cytology, embryology, serology and anatomy there has now become available a mass of evidence that was hitherto undreamt of. That the taxonomist does not readily accept this evidence is because he is conservative by nature and has a disinclination to familiarise himself with a new and more laborious field. No future classification could, however, be regarded as worthy of serious consideration unless it took the whole plant into account and not merely a part thereof.

A few instances were then cited to prove the value of anatomy in phyletic considerations. Some anatomists have been impressed by one region of the plant and others by an entirely different one. Thus Sinnott attaches particular significance to the node, Mrs. Arber to the leaf, Miss Sargant and some others to the seedling, Miss Saunders and Prof. Eames to the vascular supply of the carpel, Jeffrey to the first annual ring and the tissues produced in response to wound stimuli, Record to wood, Florin to epidermis and stomata, Netolitzky to the seed and Wodehouse to the pollen grains. Criteria of phyletic value really exist in every part of the plant and it is all a question of acquiring familiarity with the organ in question and one may then become a wood-enthusiast or epidermis-enthusiast or any other enthusiast.

Proceeding to the Centrospermales, with which the speaker had acquired special familiarity due to the work done by his post-graduate students, it was pointed out that the recent classification of Hutchinson was unsatisfactory, since it ignored the anatomical peculiarities found in members of this group. It was suggested that this may be split into two orders: *Chenopodiales* (Chenopodiaceæ, Amaranthaceæ, Phytolaccaceæ, Nyctaginaceæ, Aizoaceæ, Cactaceæ) and *Caryophyllales* (Portulacaceæ, Basellaceæ, Caryophyllaceæ), of which the former is to be regarded as the more primitive of the two. It was argued that this arrangement would satisfy the known facts of anatomy as well as floral morphology.

Finally the speaker called attention to the lack of sympathy now evinced towards anatomy and the attempt to replace it with other branches of Botany. That anatomy will always remain a valuable means of checking relationships is certain. What is needed at present is a master mind, who can visualise the entire evidence and utilise all of it instead of being hypnotised by just one organ (like the flower) and treat it as independent of the others.

K. M. Gupta, Lucknow.—The idea of anatomical structures as an aid to systematic Botany is very old. As for instance one of the first distinctions between the monocotyledons and the dicotyledons is based on the anatomy of the wood of the stem. Martius included the nature of the wood in his diagnosis of the Conifereæ. In 1910 Merkel emphasized the importance of the anatomy in perfecting the natural system of classification. In 1875 Radlkofer after the publication of his monograph on *Serjania*, a Sapindaceous genus, convincingly showed not only the possibility but a necessity of the anatomical features to be adopted as one of the most important criteria in natural classification. In 1898 Dr. Hans Solereder brought out his monumental work on the Systematic Anatomy of the Dicotyledons in two volumes. This work provides an inexhaustible store of information for every one interested in any phase of the subject. However, the work has to be extended in the light of recent progress with detailed descriptions together with accurate and suitable illustrations. More recently persons like Profs. Record, Bailey and Jeffrey have emphasized the importance of the wood anatomy in classification. Prof. Chalk of Oxford at the recent meeting of the Sixth International Botanical Congress at Amsterdam during Sept. 1935 indicated the phylogenetic value of certain anatomical features such as scalariform pits, perforation plates, fibre tracheids and diffuse parenchyma in dicotyledonous woods, pointing out the practical application in the Sympetaleæ. (Proc. vol. 2, pp. 121-122.) Enough importance, however, is now being given to the ray structures. Ray structures are sometimes extremely useful in distinguishing the woods of a small related group of plants like the Homoxylous Angiosperms. This may also help in deciphering the affinities of the related fossil woods. (Gupta 1934, Jour. Ind. Bot. Soc., Vol. 13, pp. 71-101).

From the systematic point of view the work of a Palæobotanist on the anatomy of the Primitive Angiosperms like the Magnoliaceæ (Lemeole 1933, Gupta 1934) and the fossil woods from the Jurassic and Tertiary times (Sahni 1932, Mathiesen 1932, Gupta 1935) is of considerable importance. It not only decides the taxonomic position of the investigated plants themselves, but it also throws a considerable light on the origin of the flora as a whole. Thus indicating the importance of wood anatomy as an aid to Systematic Botany, I may quote Profs. Wieland and Record as follows:— We are sure that while a better balanced understanding of wood structure present and past may never be found as directly usable in classification as floral features, any appeal to the one set of evidence without the other is no longer thinkable '. 'All we ask of the Taxonomists is a sympathetic attitude, as evidenced by a willingness to seek in their own field for a different basis of classification, one that will take the whole plant into consideration. In solving our problem they will merely be solving their own '.

N. K. Tewary, Benares, stressed microchemical reactions (plant-chemistry) in connection with taxonomy as pointed out by Prof. Hans Molisch in his book ' Microchemie der Pflanzen '.

G. P. Majumdar, Calcutta.—There is a general agreement amongst workers on plant anatomy that structural elements of the stem in vascular plants have more or less a definite taxonomic value. Families and genera can be defined on anatomical characteristics, but about the determination of species on anatomical grounds alone it is premature for me to express any opinion. Then there is the question of the different members of the plant: we have to fix the particular member whose anatomical structure should form the basis of our classification. The œcological influence should also be taken into consideration before ascribing any particular character a taxonomic value. I am, however, definitely of opinion that as a supplementary character in determining genera and species, anatomical characteristics, particularly of cortex and vascular bundles, are of great value, and many controversial points in taxonomy may be settled with

their help. This, of course, includes such special anatomical features as the occurrence, distribution and characteristics of cystoliths and other structures.

36. On the occurrence of four discrete extrastelar cauline vascular bundles in the stem of *Nyctanthes arbor-tristis* Linn.

G. P. MAJUMDAR, Calcutta.

The plants, at least the Bengal species, are characterised by the presence of four entirely separate and extrastelar cauline vascular bundles at the four corners of the young square stem. In the older rounder parts of the stem they appear as four separate superficial chords running in slightly spiral lines along its entire length.

These vascular bundles are remarkable in the centripetal differentiation of their xylem vessels, whereas the stelar xylem is centrifugal as is usual in dicotyledonous stem. This is the arrangement generally met with in the vascular Cryptogams.

They are further characterised by the phloem being disposed towards the centre of the stem—a rare phenomenon in the collateral type of vascular bundles in the Angiosperms. Regular secondary growth also takes place in these bundles.

A detailed investigation on the origin and development of these bundles has been undertaken.

37. The comparative anatomy of the roots of some Bengal Cucurbitaceous plants.

B. C. KUNDU, Rajshahi.

The writer has been studying the root structures, both normal and adventitious, of some common Cucurbitaceous plants of Bengal, and the preliminary results of the investigation have been described in this paper.

It has been found that normal and adventitious roots of the same species are not of the same type. Usually they are hetero-archic. The number of bundles always varies in the different species. The arrangement and distribution of the primary and secondary tissues of the roots of different species have been described in detail. Anomalous secondary structures have been observed in some cases.

38. Anatomical studies of the midribs of the leaves of Cucurbitaceæ from the taxonomic and phylogenetic standpoint.

H. L. CHAKRAVORTY, Calcutta.

Mr. A. Yasuda of Japan in 1904 while studying the leaves of some Japanese species has thrown a flood of light on the importance of the anatomical peculiarities of the vascular bundles of the midrib of Cucurbitaceæ from the taxonomic viewpoint. According to the number and nature of the arrangement of vascular bundles in the midrib from the proximal part of the leaf, he arranged the family into six groups. The author has examined 12 Indian species of Cucurbitaceæ belonging to 8 genera, and has verified the results of Yasuda with notes where he did not agree with him. The author believes that the arrangement of vascular bundles in the midribs as suggested by Yasuda can conveniently be applied for taxonomic purposes.

From the standpoint of reduction of vascular bundles and their arrangement in the midrib in Cucurbitaceæ, it has become possible to draw a line of phylogenetic relationships between the different members of the family.

39. The systematic anatomy of Bengal species of Cucurbitaceæ.

P. N. MAZUMDAR *and* J. N. MITRA, Dacca.

Prain describes in Bengal plants 35 species of Cucurbitaceæ in Bengal. Attempts will be made by the authors in a series of papers to study the complete anatomy of the axis and the leaves of all these species.

In the present paper the authors have studied the characteristics of the stem of the following eleven species :—*Trichosanthes dioca* Roxb ; *Trichosanthes cucumerina* Linn ; *Lagenaria vulgaris* Ser ; *Luffa acutangula* Roxb ; *Benincasa cerifera* Savi ; *Momordica charantia* Linn ; *Momordica cochinchinensis* Sprain ; *Cucumis sativus* Linn ; *Citrullus vulgaris* Serad ; *Chephalandra indica* Naud ; *Cucurbita pepo* DC.

The cortical and vascular characters have been closely studied. The cortex presents a variety of characters. Typical cortical characters with well marked hypodermis consisting of parenchyma and collenchyma, and considerable layers of cortical parenchyma are found in the majority of cases. The cortex is, however, found to be very much reduced in some species, and extreme reduction of the cortex, the endodermis coming just below the epidermis at some places, has been observed in *Momordica*, *Cucumis sativus* and *Luffa acutangula*.

In *Momordica* and *Luffa* additional bundles consisting of phloem only with internal cambium have been observed. Isolated sieve tubes, both ectocyclic and entocylic types, have also been observed.

PHYSIOLOGY AND ECOLOGY.

40. The course of transpiration in some mesophytes of Bengal. —Part II.

P. N. MAZUMDAR, Dacca.

This is a continuation of the author's investigations in the daily and annual variation in the course of transpiration. The author this time selected the following species, *viz. Gardenia florida* Linn. ; *Mureya exotica* Linn. ; *Nerium odorum* Soland ; *Citrus ducamena* Linn.

In the case of *Gardenia florida* experiments were made with two varieties, *viz.* one which flowers throughout the year, and the other with seasonal flowering only. Cut twigs were employed for the experiments.

The variations in transpiration have been correlated with variations in temperature and humidity and evaporation from the atmometer. The time of maximum and minimum transpiration in the days and year, and their variations in the same species, have been noted. The difference in behaviour in the different species has been compared with interesting results.

The regulations of the stomata have also been observed microscopically and correlated with physical measurement.

41. Variation in the course of transpiration in the presence of artificial light.

P. N. MAZUMDAR, Dacca.

In this paper of experimental Botany the author has observed the variations in the course of transpiration in the presence of artificial light, with interesting results in the following four species of plants :—*Hebiscus rosa-sinensis* ; *Ixora coccinea* ; *Jasminum sambac* ; *Vinca rosea.*

Experiments were made with cut twigs, and they were kept in darkness for some hours before they were exposed to the action of artificial light. Experiments were performed in the presence of different grades of electric lamps varying between 3,000 to 100 candle power, and the loss of water determined quantitatively every two hours.

42. Some transpiration experiments with the torsion balance.

J. C. SEN GUPTA, Calcutta.

The method of taking weights of cut twigs and leaves after short intervals has been employed during the last few years for the determination of transpiration, and is proving useful, specially for ecological investigations.

With a view to studying the transpiration of different groups of Bengal plants under natural conditions, the author has made some determinations of transpiration of some plants with the torsion balance specially modified for the purpose by Huber (Balken Torsion Wage).

An attempt has also been made to test the accuracy of the method, and to find out the conditions under which it gives reliable results.

43. The nature of the reserve food in seeds and their resistance to high temperature.

P. PARIJA *and* P. MALLIK, Calcutta.

The effect of temperature on the viability of starchy and oily seeds has been studied. The seeds were exposed to 40°, 50°, 55° and 60°C for periods ranging from 12 hours to 120 hours. It has been found that:

(i) oily seeds resist the injurious effect of high temperature much better than starchy ones,

(*ii*) among the oily seeds, the more the amount of oil in them, the higher the temperature they resist,

(iii) viability also depends on the thickness of the testa, the thicker they are, the more viable the seeds are in relation to temperature. This holds good in case of all seeds, both oily and starchy ones,

(iv) mucilage coating on testa probably affects the percentage of germination after incubation, and

(v) continued incubation decreases viability quickly at higher temperatures and slowly at lower ones.

44. Some studies on the rate of transpiration of 4-F type of Punjab American cottons.

J. C. LUTHRA *and* SANGAT SINGH, Lyallpur.

Plants for these studies were grown in glazed porcelain potometers with soils containing 10%, 15%, 20% and 25% moisture respectively. Besides, some metallic potometers of galvanised iron were used, and soil with 20% moisture was filled in them.

The rate of transpiration was compared with evaporation and maximum temperature. A high correlation between transpiration and these factors was found.

With the increase of soil moisture, there is a definite increase in the total transpiration and in the leaf area. Transpiration rate is 30 per cent of evaporation rate during September, when maximum leaf development is attained, and 31 per cent during July, when evaporation is very high.

Nearly 2,076 tons of water are lost by transpiration from an acre of cotton crop during the period of growth. Total water applied to the crop is estimated at about 2,837 tons.

Nearly one-third of the total water transpired by a cotton plant is lost in the month of September.

Maximum transpiration occurs in the afternoon between 1 P.M. and 3 P.M.

45. Some ecological aspects of the Upper Gangetic flora.

S. C. VARMA, Lucknow.

The climate of the Upper Gangetic plain is continental and due to monsoonic conditions the year is divided into three seasons viz., (I) the rainy season from the end of June to the end of October, (II) the winter season from November to February, and (III) the summer season from March to the end of June.

The rainy season had 94·8 per cent. of the annual rainfall, and owing to favourable climatic and edaphic conditions, the tropical luxuriance of the flora was prominent. In a metre quadrat 509 plants (exclusive of grasses), the largest number of the year, were recorded during this season.

Lower temperature and dry winds were characteristic of the winter season, and the tropical plants were gradually superseded by temperate ones. The number of plants per metre quadrat gradually decreased to 356 in December and 82 in February. There was great range between maximum and minimum temperatures, which resulted in the precipitation of copious dew, and this to some extent compensated for the absence of rain during the season. The amount of water contained in the surface layers of the soil showed a gradual decline.

There was intense drought during the summer and all plants excepting xerophytes and trees were dried up. The leaves of most of the deciduous trees fell off at the beginning of summer. The new leaves appeared at the height of summer and it seems very unlikely that the leaf-fall helps the trees to tide over the drought period.

The plants of these localities are most conveniently classified into synusia (Gams). According to Dudgeon the present vegetation is in the dry meadow stage and would develop into a deciduous monsoon forest if left undisturbed by man. Man for his economic needs controls the surrounding vegetation, and there is hardly any hope for the vegetation to reach its climatic climax so long as man lives in that locality. The vegetation of a locality modified by the presence of man, and which has attained stable equilibrium, may be termed a Biotic Climax.

46. On the nature of competition between plants in the early phases of their development.

S. C. VARMA, Lucknow.

In biology the term competition implies struggle between two living organisms for a limited supply of the necessaries of life. It is of extreme importance among plants.

The competition is severest at the seedling stage, and it almost ceases between adult plants. There is minimum competition when identical individuals are competing. The severity of competition between individuals making identical demands increases with the increasing difference of their biological equipment, but only to a certain stage. After this stage is reached the severity again decreases as the competing plants begin to occupy different soil and air regions. In a climax plant-community the competition is reduced to a minimum.

The living and also the decaying roots of plants probably produce toxins in the soil, which affect more adversely the growth of another species than the one producing them. The toxins from different plants probably vary both in their chemical and physical properties and in their manner of production. The toxins may, therefore, be acting as a weapon useful to a plant to depress the vigour of its competitors.

The structural and physiological response of the plants to the toxins appears to show that the toxins probably operate by retarding the root development, and by disturbing the normal intake of water and salts by them.

The resources of plants are more severely taxed when they are growing in mixed than in pure cultures, and in response they develop devices with which they either evade or overcome the adverse effects of competition. There is stringent selection at the seedling stage of the fittest and the elimination of the unfit. There is no paradise for plants.

If plants in competition be supposed to produce genotypical response, then competition may be a contributory cause to the production of new species.

47. Chlorophyll content and assimilating capacity of (1) the immature seeds of *Crotalaria juncea* Linn., and of (2) *Cuscuta reflexa* Roxb., parasitic on *Duranta plumieri* Jacq.

P. PARIJA *and* K. SAMAL, Cuttack.

(1) Green pigment is found in the embryo of *Crotolaria juncea* from its early differentiation. The cotyledons, plumule, radicle and even the hole of the suspensor look quite green. The amount of chlorophyll gradually decreases as the embryo matures, and the fully mature seeds contain no chlorophyll. Using Schertz's method with slight modifications, chlorophyll was estimated colorimetrically in comparison with Gutherie's chemical standard. Half-matured embryos (testa taken off) contain 0·061% of chlorophyll (α and β combined) on the basis of fresh weight. The relation of chlorophyll α to chlorophyll β at this stage of maturity is nearly 2 : 1. The spectrum of the chlorophyll α and chlorophyll β together show absorption bands similar to those of the chlorophyll extracted from the leaves of the same plant. Two dark absorption bands in the red-region of the spectrum are quite clear. The photosynthetic capacity of these green embryos was measured ; 12·5 gms. of the half matured seeds assimilated 7·5 c.c. of CO_2 during 3 hours of a bright sunny day in the month of August when the temperature was 31°C. The assimilation number was found to be 1·5, which indicates comparatively low efficiency.

(2) The chlorophyll content of *Cascuta reflexa*, as well as its assimilating capacity, has been determined by the same methods. It is found that :

(*a*) it contains 0·0036% of chlorophyll on the basis of fresh weight,
(*b*) the ratio between chlorophyll α and chlorophyll β is 3 : 1,
(*c*) 50 gms. of fresh cascuta assimilate 10·7 c.c. (N.T.P.) of CO_2 at 31°C on a bright sunny day ; its assimilation number is 3.

48. The relation between the water content and the germinating capacity of the seeds of *Phaseolus mungo* Linn, Var. *Roxburghii* Prain.

P. PARIJA *and* K. SAMAL, Cuttack.

Seeds of *Phaseolus mungo* Linn, Var., *Roxburghii* Prain, roughly selected by the uniformity of size and colour, were dried at the ordinary

temperature by sucking a current of air made dry by passing it through conc. H_2SO_4 and fused $CaCl_2$.

Seeds in lots were taken out at intervals, and one half of the lot was used for finding out the water content and the other germinated in comparison with ordinary air dried seeds as control.

The ordinary air dried seeds contain 11·6% of water. Up to date the drying has gone so far as to reduce this percentage to 4·7.

It has been found that with the progress of drying,

(1) the cotyledons are the first to be affected, as they show progressive browning which makes its first appearance when the seeds contain 7·53% of water;
(2) the percentage of germination gradually falls, thus 11·67%, 100; 8·93%, 98; 8·07%, 96; 7·53%, 94; 7·38%, 90; 6·92%, 90; 6·63%, 88; 5·1%, 78; 4·8%, 75; 4·7%, 74;
(3) the less the water content of the seeds, the thinner and shorter are the seedlings raised from them;
(4) dry weights of the seedlings from normal air-dry seeds and from seeds at various stages of drying have been determined at a definite age of the seedling. The ratio of the dry weight to the fresh weight of the seedlings increases as the percentage of water falls in the seeds;
(5) the deficiency is probably due to the lessening of available food in the cotyledons, because the seedlings make up in the ratio between fresh and dry weight as they start assimilating.

The work is in progress.

49. An ecological study of the vegetation of the Raveyres.

F. CHODAT (Geneva) *and* P. ANAND, Lahore.

This investigation was carried on at the Linnæa, Alpine Biological Station, Bourg-Saint-Pierre, Switzerland.

Four distinct formations have been distinguished; viz.

1. The *Rock*-formation consisting of *Sempervivetum*-and *Festucetum ovina*-associations.
2. The *Prairie*-formation consisting of *Laserpitietum*-and *Trifolietum*-associations.
3. The *Vire*-formation dominated by *Festucetum varia*-association.
4. The *Rimaie*-formation consisting of a marginal zone dominated by *Vaccinietum myrtillus* and *Geranietum silvatica* and a central zone dominated by *Chærophylletum hirsuti*.

The various associations have been further divided into communities which are described in detail in this paper.

Soil samples were collected from these communities and the following observations noted with regard to each sample:—

1. Mechanical analysis.
2. Content and capacity of air.
3. Content and capacity of water.
4. Actual acidity of the soil.
5. Buffer action.

It is seen that a definite correlation exists between variations in the soil and the floristic composition.

A study of the root systems of the dominant plants of each community has also been made.

PALÆOBOTANY.

50. The anatomy of *Tæniopteris spatulata* McClelland.

A. R. RAO, Lucknow.

The mesarch nature of the vascular bundles of the midrib, as well as the cuticular features of *T. spatulata* McCl., have already been recorded (Rao. *Proc. Ind. Sci. Congress*, 1934). Further examination reveals the following anatomical details. The tip of the leaf is acuminate, and a thin layer of cutin covers the epidermis. Beneath the upper epidermis lies the palisade, generally one cell thick and extending over the midrib also, and succeeded by spongy parenchyma several cells thick; the lateral veins which arise almost at right angles from the midrib course between these two tissues. Annular, spiral and scalariform elements of the midrib bundles can be clearly made out. In vertical longitudinal sections the lateral veins underlie depressions of the surface suggesting a finely grooved lamina. Each vein is enclosed in a sclerenchymatous sheath, and over each bundle is developed a certain amount of hypodermis, two cells of which above and below are rather prominent. The short petiole seems to be slightly winged and has a ventral groove. Complete or attached leaves are never met with, probably due to their crisp and deciduous natures respectively.

51. Winged pollen from the Jurassic of India.

A. R. RAO, Lucknow.

The two-winged and three-winged pollen recorded from the Rajmahals (Rao. *Proc. Ind. Sci. Congress*, 1934) are described in detail. The species can be referred to Professor Seward's form genus *Pityosporites*.

52. Fossil woods from Queensland.

H. S. RAO, Lucknow.

The anatomy of certain Gymnospermous woods, mostly *Dadoxyla* from the base of the Brisbane tuffs as exposed at Collin's Wharf (Permo-Carboniferous), is described. All the specimens show clearly the growth rings. They are silicified and well preserved, consisting only of the secondary wood.

53. On some Jurassic plants from old and new fossiliferous localities in the Rajmahal hills.

K. M. GUPTA, Lucknow.

Although the Rajmahal Hills form one of the most important localities for Jurassic plants, not many fossiliferous exposures were known to earlier workers such as Feistmantel. The object of the present paper is mainly two-fold: firstly to put on record the discovery of some new fossiliferous localities, together with the species collected from them. These were discovered during the excursions of the years 1931, 1934, and 1935 in all of which the present author took some part. Secondly the object is to describe briefly a few and interesting types. Among the important types described here are the following:—

A species of *Hausmannia*, a Dipteridaceous leaf impression described for the first time from India; one or two new species of *Rhizomopteris*, a genus intended to include stem or rhizome-impressions of ferns of doubtful affinity and some new fern and cycadean leaf and stem-impressions besides a well-preserved *Williamsonia* fructification. Lastly, a new light

has been thrown on the structure of certain cone-like bodies (including *Conites sessilis* Sahni) which have been found to be not cones but probably of the nature of short shoots. They may possibly belong to the genus *Tæniopteris* so profusely found in association with these shoots.

54. *Leguminoxylon burmense* Gen. et sp. nov. a dicotyledonous wood from the Tertiary of Burma.

K. M. GUPTA, Lucknow.

This material from the Irrawady System of Burma was received by Prof. Sahni in 1921 from the Director of the Geological Survey of India. Prof. Sahni, who originally intended to describe this fossil, regarded it as probably specifically identical with *Dipterocarpoxylon burmense* Holden, with a number of structural features hitherto unnoticed (Sahni, 1922). But its recent examination by the author proved its distinct identity from that of *D. burmense* Hold., now known as *Irrawadioxylon burmense* (Hold.) Gupta (Gupta, 1935). Besides this material from the Geological Survey of India, a few more sections of *Leguminoxylon burmense* Gen. et sp. nov. are available for description through the kindness of the authorities of the Madras Museum. It is described under the more comprehensive name *Leguminoxylon*, Gen. nov., rather than a restricted genus like *Caesalpinioxylon*, due to its resemblances to leguminous woods rather than cæsalpinious. This new genus will also have the advantage of embracing such fossil dicotyledonous woods whose affinities with the living genus of the family Leguminaceæ are indeterminable. The structure of the fossil may be briefly described as follows :—

Growth rings absent or faintly marked, vessels isolated or in radial rows of 2 or 3 ; simple pits on radial and tangential walls of vessels ; wood parenchyma vascicentric in form of well defined rhomboid masses round the vessels. Medullary rays usually 2-3 seriate, 6-18 cells high ; ray cells all similar, narrow and horizontally elongated. Resin canals absent, but resin present in the ray cells. The specimen has been compared with living and fossil leguminous woods.

The sections and photographs were exhibited.

Section of Zoology.

President:—Dr. H. K. Mookerjee, D.Sc. (Lond.), D.I.C.

Presidential Address.

THE DEVELOPMENT OF THE VERTEBRAL COLUMN AND ITS BEARING ON THE STUDY OF ORGANIC EVOLUTION.

I am deeply grateful to you for the honour you have shown, in electing me to this chair, and, while offering you my most sincere thanks, I would respectfully beseech the co-operation of the members of the Congress to make it a success. Year after year the general convention appears to be that the President's address should deal with a subject in which he is interested, and it should give a generalized statement of his own researches. I have, therefore, chosen 'The development of the vertebral column and its bearing on the study of organic evolution' as the subject of my address.

Introduction.

No problem is more fascinating to a biologist than that of organic evolution. Organic evolution in some form or other was believed to be true by a number of naturalists, long before the birth of Darwin. In fact, the idea of such evolution is of very old origin and one can trace it to even before the time of Aristotle. But it was left to the genius of Darwin to state the laws, as he did, of organic evolution, supported by the evidences that were available in those days. Biology has made long strides since then, and, while the central concept of the Darwinian theory holds good, numerous changes have been suggested in explanation of the supporting facts. It is not the theory of descent, but it is the facts on which the theory is based, that we are more concerned with.

The knowledge of embryology was not much in advance when Darwin propounded the theory of organic evolution in a definite form in his epoch-making book *The Origin of Species*. Nevertheless, embryological and morphological facts, more than the data from palæontology, were adduced as indirect evidences of organic evolution. Darwin (2) says, 'Embryology rises greatly in interest when we look at the embryo as a picture, more or less obscured, of the common parent form of each great class of animals'.

The theory of evolution means descent with modifications; but we feel great difficulty, owing to the imperfections and gaps in the series of any class of extinct forms showing gradual evolution from the so-called lower to its modern form, in tracing the line of descent, that is to say, the phylogenetic affinities. The theory of recapitulation is a help in the matter. According to this theory, the ontogeny, that is, the developmental history of an organism from the egg stage to the adult, repeats the phylogeny, that is, the racial history. Therefore, from the mode of development of an organism we can picture its ancestral forms. Such questions as the mono- or poly-phyletic origin of a group of animals, which often agitate the mind of a systematist or palæontologist and imply divergent or convergent modes of evolution, can also be answered by examining whether there is a uniformity of developmental processes in the members composing the group or not. For this purpose development of similar organs in the different members of the group, should be carefully studied, and such organs should be selected as are relatively stable and are not easily adaptable or plastic. To facilitate correlation with such other facts as affect the evolutionary history of the group, the type of organ to be selected for embryological studies should be one about which we have more or less comparative data relating to other aspects of its evolutionary history. The study of development of vertebral column of the vertebrate group meets with all the above requirements. I propose now to deal with the development of the vertebral column which I have been investigating for a number of years, and shall try to show evidences from the study of this embryological problem in support of the theory of organic evolution.

Towards the middle of the nineteenth century, the problem of the development of the vertebral column attracted the attention of continental embryologists. Most of them approached the problem and endeavoured to solve it according to the material and knowledge available in those days, until Gegenbaur (13) came in and tried to systematize the knowledge so far gathered, making his own contributions as well. Gegenbaur's conceptions were sometimes wide of the mark, owing no doubt to the fact that microtomic work was not perfect in those days. Towards the close of the nineteenth century Gadow (8, 9) became interested in this problem and published his observations in the *Philosophical Transaction of the Royal Society, London.* His object was to co-ordinate the works of previous investigators, but, despite his great knowledge, discernment and industry, the solution of the problem remained unattained, while complications appeared to some extent. He was often emphatic in his assertions, and though he was contradicted by more than one embryologist, he with his peculiar arguments, tried to justify himself. In spite of these drawbacks, one should look

upon him as the pioneer in this field of research, and even to-day his two papers, and his posthumous book on ***The Evolution of the Vertebral Column***, are often quoted in reference to problems connected with the development of the vertebral column.

The development of the vertebral column of all vertebrates can be studied under the following heads :—

1. Formation of the centrum or the body of the vertebra.
2. Formation of the arches both upper and lower.
3. Formation of the ribs and the rib-bearing process.
4. Formation of the articulations.

In vertebrata, the notochord is the starting element in the formation of the vertebral column. It is rather a stiff but flexible rod lying below the central nervous system, and wedged between the paired series of muscle segments. The notochord generally develops from the dorsal wall of the archenteron as a thickening which is ultimately nipped off from before backwards. After repeated divisions of the nuclei, the cells of the notochord multiply and become vacuolated forming the characteristic notochordal tissue of polygonal cells. At the periphery, an epithelium is formed of cells rich in protoplasm which secretes the two covering sheaths ; first, a thin cuticular membrane called the *elastica externa*, and, later, a thick fibrous sheath inner to the first, called the *elastica interna*.

According to the previous workers on the development of the vertebral column, the mesoderm on the lateral sides of the notochord differentiates out into protovertebral and lateral plates. The protovertebra in its turn, divides into somites which are arranged one behind the other. The sclerotome is a cluster of cells liberated from the ventro-medial corner of the primitive hollow somite (whose outer wall forms the cutis layer), while the myotome is only a thickened portion of the inner wall of the somite. In case of teleostean fishes, amphibians, and in some of the reptiles, the sclerotomic cells become scattered right from the beginning, so that the sclerotome, i.e., the cluster of sclerotomic cells, does not take a definite position immediately after the cells had been liberated from the ventro-medial corner of the mesodermal somite. In other cases, the sclerotomes enlarge, forming blocks closely packed together and extending to the notochord. Each sclerotome is differentiated into two halves, and sometimes there is a clear fissure between these two halves. The posterior half of the sclerotome is usually more dense and compact than the anterior half, the latter to some extent, is invaded on the dorsal side by the developing spinal nerve ganglion.

Owing to the sclerotomes retaining their individuality for a considerable time, frontal sections of embryos show alternate light and dark stained half sclerotomes. Each light anterior half-sclerotome of a segment, say X, fuses with the dark posterior

half-sclerotome of the segment, say, Y, preceding it, to give rise to a complete vertebral segment. Thus the resegmentation is formed leading to the alternation of vertebræ with the original somites. Intervertebral portions are intramyotomal and the vertebral portions are intermyotomal in position.

Sclerotomes of opposite sides fuse towards their inner ends adjoining the notochord, to form a continuous skeletogenous perichordal layer. The dorsal part of the denser half-sclerotome is known as the *basidorsal* and the ventral part of the same as the *basiventral*. The dorsal part of the lighter half-sclerotome is the *interdorsal* and the ventral part of the same the *interventral*.

Gadow (9, 11) classified the vertebræ into two main divisions according to the mode of the formation of the centrum. These divisions are :—

I. *Chordacentrous*. The sheaths of the notochord become the centrum. The mesoblastic cells from the skeletogenous layer which were originally outside the sheaths, in all Elasmobranchs, make their way through the thin elastica externa and invade the underlying fibrous sheath in every segment at four points in its circumference corresponding to the bases of the dorsal and ventral arches. These cells penetrate in large numbers, arrange themselves in concentric layers, and contribute a matrix to the ever-widening fibrous sheath. The centra are thus formed from the notochordal sheaths.

II. *Archocentrous*. The arches (*arcualia*) play an important rôle in the formation of the centrum. This second division, according to Gadow, can be subdivided into three main subdivisions :—

(*a*) *Pseudocentrous*. Four pairs of arcualia, viz., *basidorsalia*, *basiventralia*, *interdorsalia* and *interventralia* take part in the formation of vertebral centrum. Basidorsalia and basiventralia are fused together to form the middle of the vertebral body, as in the caudal vertebræ of Urodela.

(*b*) *Notocentrous*. The centrum is formed by basidorsalia, interdorsalia and basiventralia. Example of such a vertebral centrum can be found in the trunk vertebræ of Anura. Gadow further divided this subdivision into two sections :—

Epichordal. The basiventralia are suppressed ; example of this can be found in *Xenopus*, *Bombinator*, etc.

Perichordal. The basiventralia take part in the formation of the centrum. Example of such a centrum can be found in the trunk vertebræ of the common frog.

(*c*) *Gastrocentrous*. Here the basidorsalia, interventralia and basiventralia are present. But the centrum is formed mainly from the interventralia. Basiventralia are much reduced and form the intervertebral disc attached to the cranial

TYPES OF VERTEBRAE → ARCHOCENTROUS

TELEOST

CHORDACENTROUS
ELASNOBRANCH

PSEUDOCENTROUS
URODELA

URODELA

PERICHORDAL
ANURA

NOTOCENTROUS
ANURA

URODELA

ANURA

GASTROCENTROUS
AMNIOTA

EPICHORDAL
ANURA



CLASSIFICATION OF VERTEBRA BY GADOW

H. K. Mookerjee *By courtesy of 'Current Science'*

surface of the centrum; when less reduced they appear as so-called wedge-bones the intercentra or chevrons, as in the trunk and tail vertebræ of most Amniota (Plate 1).

The validity of the above classification of the vertebræ, in general, has often been questioned by me and by my collaborators, not only in reference to any particular species but with regard to several species of the vertebrate class.

If the theory of gradual evolution be held correct, such a wide range of diversity in the formation of the vertebral centra as outlined above by Gadow, is rather difficult to correlate and explain, specially when it is well known that there is nothing more rigid and nonplastic than the skeletal system in the animal kingdom, and the origin of this structure in the animal kingdom by mutation is problematic.

FORMATION OF THE CENTRUM OR THE BODY OF THE VERTEBRA.

After the formation of the notochord and its sheaths, the skeletogenous cells aggregate round them forming an outer jacket of cells known as the *perichordal layer.* In the case of Elasmobranch, the cells of the perichordal layer soon pass inside the inner fibrous sheath at four points, that is, at the bases of arches of each segment. These mesenchymatous cells, on reaching the fibrous sheath, soon become cartilaginous and form the centrum. Therefore, Gadow's interpretation of the chordacentrous type could partially be held as correct in so far as the ultimate formation of the centrum by the notochordal sheaths is concerned, but with this difference that the centrum formation in the beginning is greatly aided by the skeletogenous cells which migrate within the notochordal sheaths. In Teleostean fishes, the skeletogenous layer aggregates round the sheaths of the notochord as in the above, to form the outer jacket known as the perichordal tube. These cells, it should be noted, do not get inside the notochordal sheath as in the Elasmobranchs. This perichordal tube, laid outside the notochordal sheaths, becomes cartilaginous and eventually becomes osseous in the vertebral region. In a generalized Teleost, like the Herring, Ramanujam (44) has shown that there is an intermediate stage, between the Teleost and the Elasmobranch, in which the skeletogenous cells form an outer ring corresponding to the perichordal tube, the inner ring of bone being the result of ossification of the fibrous inner sheath of the notochord. Ramanujam interprets that mesenchymatous cells have actually migrated from the bases of the mesenchymatous neural arch, although he could not establish this except in one or two stray cases. Whether the skeletogenous cells get inside the fibrous sheath of the notochord at the bases of the cartilaginous arch, as in the Elasmobranch, or the mesenchymatous cells become

actually severed and migrate inside the sheath, is a problem that requires further investigation.

According to the previous authors (8, 18, 19, 22, 25, 46), in the vertebral column of *Amia calva*, each thoracic vertebra has a centrum formed by the base of the arch, which, together with the skeletogenous layer, constitutes a ring round the notochordal sheaths. Two separate centres of chondrifications of the arch start corresponding to the anterior and the posterior halves of each centrum, the anterior portion being formed by the base of the arch, and the posterior by the arch proper or the basidorsal.

According to my investigation carried on in collaboration with Das, however, the so-called base of the arch does not belong to the arch but is a part of the perichordal tube. The so-called base apparently looks as such because the perichordal tube is not uniform in thickness along its length and in each anterior half of the centrum, is given off towards the dorsolateral direction a pyramid-shaped outgrowth that is apt to be mistaken for the base of the arch. Schauinsland (46) regrets that none of the workers, including himself. could get the earlier stages of *Amia calva*. We were fortunate enough to get the very early stages of this species and found that the so-called base of the arch at the early stages was in a mesenchymatous condition exactly like the remaining perichordal tube, while the arches were easily distinguished from the latter in being cartilaginous. The same was also true in case of the so-called base of the basiventralia.

In the intervertebral region of the ordinary Teleost, mesenchymatous connective tissue cells form by migration three consecutive rings arranged in a series around the perichordal tube which remains membraneous for a considerable time (33). I was the first to discover the existence of this sort of migratory connective tissue cells in the intervertebral portion of the perichordal tube of the vertebrate series beginning from Elasmobranchs right up to Mammals. These migratory connective tissue cells are responsible for the origin of different kinds of vertebræ. I shall show later on, when I shall speak of the formation of articulations, how different forms of vertebræ are actually formed by the help of these migratory connective tissue cells.

According to Gadow (9, 11), the development of the vertebral centrum of all Urodela starts with a uniform aggregation of the skeletogenous layer outside the notochordal sheaths. There is no trace of segmentation into the vertebral or the intervertebral region. He gave the name '*membrana reuniens*' to this undifferentiated layer and to the remnants of it, which persist after the cartilaginous structures had been derived from it. The dorsal arcualia become cartilaginous at the same time. The intervertebral ring of cartilage is formed from two

interdorsalia and two *interventralia*, that is, from four centres of chondrification.

I (28) have clearly shown that it is possible to differentiate the skeletogenous layer deposited external to the notochord into (i) perichordal rings, and (ii) mesenchymatous tissues which fill the interspaces between the successive perichordal rings; and these two together constitute the perichordal tube in a higher Urodela such as *Triton vulgaris.* Gadow's definition of membrana reuniens is not correct, because the intervertebral cartilage actually is formed from this perichordal ring; while the mesenchymatous tissue between two successive rings becomes ossified, forming an hour-glass-shaped centrum. The waist of the hour-glass corresponds to the intermyotomal (vertebral) region, for there is no other structure there except this mesenchymatous tissue. Its two free projecting ends partially surround the perichordal ring (or intervertebral cartilage) and a space is left between the consecutive hour-glasses, thus allowing the perichordal ring of cartilage partly to go unprotected.

The sclerotomic perichordal ring becomes cartilaginous all at once, and the existence of four different centres of chondrification cannot be justified. Emelianoff (5) also lends support to this view. A strand of migratory connective tissue cells passes into the cartilaginous perichordal ring through the space left between the consecutive hour-glasses, resulting in the formation of an arc, the convex surface of which is directed towards the cephalic end. A split appears within the body of the arc composed of connective tissue cells, so as to give rise to the formation of a synovial cavity. The intervertebral cartilage thus is divided into a ball and a socket, so that each vertebra has the ball in front and a socket at the back, to form the opisthocoelous type.

Schauinsland (46) and Kerr (25) have stated that the intervertebral cartilage in Urodela increases considerably in thickness, bulging out between the adjacent and somewhat expanded ends of the bony tube. The statements of both the authors, I am afraid, are untenable; one could satisfy himself by determining whether it is a bulging or this has been produced by the migration of connective tissue cells from outside, simply by comparing the sections of an early stage with those of a later stage. In the early stage, the migratory connective tissue cells are outside the intervertebral cartilage, whereas at a later stage they are found within the intervertebral cartilage, and this substantiates what I have said.

Gadow (9) has stated, "In many Urodela, especially in Perennibranchiata the whole intervertebral cartilage acts as the joint, being, in fact, a flexible mass intercalated between the bases of the hollow calcified cones of the successive vertebræ. However imperfect this joint may be, it does fulfil the require-

ments of these long-bodied and long-tailed aquatic Urodela". Subsequent authors like Schauinsland (46), Kingsley (26) and Goodrich (19) have supported this statement of Gadow.

In lower Urodela such as in *Necturus maculatus*, I, in collaboration with Das (36), have reported an almost identical condition as found in *Triton vulgaris*, with this difference, that, after the formation of the hour-glass-shaped centra and the cartilaginous intervertebral rings, the migratory connective tissue cells instead of getting into the intervertebral cartilage through a curved path to form an arc, pass at right angles to the intervertebral ring of cartilage. The migratory connective tissue cells soon become converted into a ligament.

In the other lower Urodela, namely *Amblystoma tigrinum*, the formation of the vertebral centrum is quite different from that of *Triton vulgaris* as well as from *Necturus maculatus*. After the formation of notochord and its sheaths, in the intervertebral regions, the development of perichordal ring of skeletogenous tissue begins. These skeletogenous cells soon become cartilaginous, having one centre of chondrification like that in *Necturus maculatus*, with interspaces between the rings filled in by ordinary mesenchymatous tissues. A curious and unexpected difference from that of *Triton vulgaris* and *Necturus maculatus* is that the mesenchymatous tissue which fills up the space intervening between the consecutive cartilaginous rings of the intervertebral regions as mentioned above, does not envelope the whole of notochordal sheaths, but only the dorsal part of the latter, the rest of the notochordal sheath remaining unprotected. The mesenchymatous tissue extends over and partly overlaps the edge of intervertebral cartilaginous ring but in such a manner that the overlapping edge of the mesenchymatous tissue does not meet that of the next of its kind; consequently there remains a gap. The enveloping mesenchymatous tissue soon becomes osseous forming a very narrow hour-glass-shaped centrum. The two ends of the hour-glass appear in cross-section, as circular osseous rings, whereas the waist of the hour-glass is a semicircular arc because of the fact that it is made up of mesenchymatous tissue restricted only to the dorsal side of the notochord.

Up till now none of the authors has described a vertebral centrum in which the middle portion is like the above arc in the Urodela. In the case of some Anura, Gegenbaur (13), Gadow (9) and others no doubt, have described the vertebral centrum the cross-section of which is like an arc; but the mode of development and the constituent elements of that as given by these authors are quite different from the one described here.

Goodrich's (19) statement regarding the mode of development of the vertebral centra of the Urodela in general, is the same as I have observed in *Triton vulgaris*. Incidentally it may further be mentioned that the figure given by him, of the

reconstructed as well as of the sagittal section, of the vertebral centra of *Amblystoma tigrinum*, is an exact representation of what is seen in *Tr. vulgaris*. This seems to have been created by an error in course of reconstruction of figures. I am inclined to think so, because the sections of *A. tigrinum* gives altogether a different picture from the above and the study, which I have made in collaboration with Das on *A. tigrinum*, reveals the fact that the waist of the centra is deeply depressed ventrally in this species ; and even a naked-eye examination of the side-view of a dried adult vertebral column would corroborate our statement.

In the tail region of *A. tigrinum* the skeletogenous layer forms the perichordal tube external to the notochordal sheaths. The ossification is restricted, however, to two portions : one on the dorsal side and the other on the ventral side of the notochord—thus forming two arcs. These two ossified arcs are connected on the lateral sides by the persisting mesenchymatous tissue.

Now according to Gegenbaur (13) the development of the vertebral body in Anura takes place as follows : soon after the formation of the notochord and its sheaths, the skeletogenous tissue cells aggregate on the dorso-lateral corners of the notochord to form the neural arches (dorsal arcualia). They rest directly on the sheaths of the notochord. These arches correspond in position to the caudal half of each myotome, while the spinal nerve ganglia correspond to the cranial half. In the mean time, another mass of skeletogenous tissue is formed mid-ventral to the notochord. Ultimately these skeletogenous aggregations become cartilaginous. These cartilaginous elements are connected with each other by the connective tissue to form a complete ring. Thus the basal portion of each arch is prolonged dorsally as well as ventrally so that the two unite to form a complete ring of cartilage which becomes the osseous vertebral centrum. This method of development of the vertebral column should be called the perichordal mode. The development of the vertebral body of both *Rana* and *Bufo* follows this mode. There is another mode of development of the centrum called the *epichordal* mode, in which the ventral element remains membraneous and ultimately degenerates along with the notochord. The centrum is thus formed only from the bases of the dorsal arcualia. This mode is shown in the centrum formation of *Pseudis*, *Bombinator*, etc.

Schwegmann (47) and Gadow (9, 10, 11) have supported the statement of Gegenbaur.

I (29) have worked on four different examples, viz., species of *Rana*, *Bufo*, *Bombinator*, and *Xenopus*, and have found that the perichordal mesenchymatous tissue in each case envelops the notochordal sheaths both in the vertebral as well as in the intervertebral regions. The perichordal layer so formed is very

thin in that region where the bases of the arch come in contact with it. Consequently it apparently looks as if the arch sits directly on the notochordal sheath. The thinness of the fibrous perichordal layer on the two dorso-lateral corners, however, is obviously due to the pressure exerted by the congregation of the sclerotomic cells that form the dorsal arcualia. In fact, the dorsal arcualia have nothing to do with the formation of the vertebral centrum. In the cases of *Rana temporaria* and *Bufo melanostictus*, it is the fibrous part of the perichordal tube, situated just below the cartilaginous dorsal arcualia that first becomes chondrified. The cells of this portion are quite distinct from the cartilaginous cells composing the dorsal arcualia. The early chondrification of the perichordal tube near the bases of the dorsal arcualia has led to the mistaken notion that the cartilaginous arcualia sit directly on the notochordal sheath.

From the description given by Gegenbaur (13), Schwegmann (47), Gadow (9), and Schauinsland (46), it seems that these authors regarded the structural condition of any particular portion of the vertebral columns of *Rana* and *Bufo* examined by them, as typical of the general structure of the entire trunk vertebra, as otherwise we cannot comprehend how they could describe a trunk vertebra to be formed almost in the same way as any other vertebra belonging to the anterior portion of the urostyle in spite of the fact that the vertebræ of the two regions are different. Schwegmann (47) and Gadow (9) have stated that they started sectionising from the tail end of the tadpole and most probably the other two workers did likewise and went up to the anterior end of the urostyle but not beyond it; we infer this because we find that there is no separate ventral cartilage present there such as they assumed, to represent the united pair of hæmal arch elements in the trunk vertebra.

Ridewood (45), who worked on *Xenopus* and *Pipa*, is of opinion that the arcualia sit directly on the notochordal sheaths. The mesenchymatous tissue below the spinal cord and between the bases of the arches becomes cartilaginous; and there is formed in addition, in the case of *Xenopus*, a cartilaginous body, squarish in section, below the notochord. Ridewood was unaware of what ultimately happened to the rectangular cartilage below the notochord.

Xenopus lævis presents a unique and most interesting case. The chondrification of the perichordal tube starts just as in other cases, first in the region beneath the basidorsals and then extends to the mid-dorsal region. *Xenopus* has a rectangular cartilaginous structure ventral to the notochord which Ridewood thought to be homologous with the hypochordal cartilage of *Rana* or *Bombinator* in the urostyle region. Ridewood emphasized this homology since nobody previously had reported a hypochordal cartilaginous structure in the trunk

vertebræ of an animal belonging to Anura. He, however, failed to elucidate the ultimate fate of this.

Really the rectangular structure cannot be homologised with the hypochordal structure described by Goette (16) in *Bombinator*. It is not placed outside the fibrous perichordal tube but forms an integral part of it, so that in *Xenopus* in the vertebral region, there is a semi-circular cartilage present at the base of the dorsal arcualia in addition to a rectangular cartilaginous structure placed ventral to the notochord, and the fibrous layer on the sides connect these two structures so as to complete the ring. At a later stage the rectangular structure degenerates together with the notochord and two lateral connective tissue masses. The adult centrum is formed from the upper semi-circular cartilage.

In *Bombinator igneus* the perichordal tube chondrifies first beneath the bases of the dorsal arcualia, and then mid-dorsally, but the ventral portion, instead of chondrifying, degenerates along with the notochord. According to Emelianoff (5) the same sort of development of the centrum of the trunk vertebra takes place in *Pelobates fuscus*.

The general classification of the formation of the vertebral centrum of Anura based on the perichordal and the epichordal modes, as defined by Gadow, is sound in certain respects, although the centra are not formed from the arcualia as previous workers have assumed, but from the perichordal tube. In the perichordal mode of development exhibited by *Rana* and *Bufo*, the whole tube of the vertebral region becomes chondrified and converted into centra; in the epichordal mode, (e.g., in *Bombinator, Xenopus*) only the dorsal portion of the tube forms the centra. The first, or the atlas vertebra, in all Anura, however, is formed from the chondrification and ossification of the entire perichordal tube.

According to Gadow (9), the intervertebral element is derived from four centres of chondrification, the two interdorsal and two interventral cartilages, like the basidorsals, being quite distinct. The interdorsal element is very prominent and in the case of *Rana*, constricts the notochord in the dorso-lateral zone, whereas in the case of *Bufo*, it grows obliquely downwards and inwards. Interventral element plays a less important part in these instances.

I (29) have shown, that, after the dorsal arcualia have become cartilaginous, the perichordal tube of the vertebral portion is checked in growth, the zone of growth being transferred to the intervertebral portion. So the perichordal layer between the two cartilaginous arches, acquires the form of a thick semi-circular ring whose middle portion is the thickest and the two sides tapering and slender. A little later the pressure exerted by the growing intervertebral fibrous tissue on the notochordal sheaths, constricts, to a great extent, the notochord at that

region. But the growing tissue does not expand uniformly around the notochord. In *Rana*, it constricts the notochord, first, on dorsal side, the pressure from the dorso-lateral corner passing towards the ventral side; but in *Bufo* the pressure is directed, first, towards the ventral surface, and then inwards and upwards. The result is that in the two genera, the transverse sections of this region are absolutely different. The perichordal fibrous layer later becomes pro-cartilaginous. The transformation from fibrous tissue to pro-cartilaginous, starts from the dorsal region. As there is no sharp line of distinction between the dorsal and the ventral regions, we cannot discriminate the interdorsal from the interventral. The best thing, therefore, would be to indicate them as the intervertebral ring of cartilage. After this intervertebral body has become pro-cartilaginous, a vortex of migratory connective tissue cells passes across in a slanting manner through the cartilaginous body resulting in the formation of a track in the shape of an internal arc within the latter. The connective tissue cells on getting inside the intervertebral pro-cartilage in this way, split up into two strands each following the line of the arc. Subsequently these become cartilaginous. The split gives origin to the synovial cavity; and the ball and socket thus formed respectively fuse with the two consecutive vertebral bodies. In *Rana,* as well as in *Bufo,* the general structure of the vertebræ comes under the procoelous type, and, this is so because the connective tissue cells invading from the sides, pass in from a craniocaudal direction so as to produce the socket at the head end and the ball at the caudal end. Thus we get in each vertebra anteriorly a socket and posteriorly a ball.

In *Bombinator igneus,* where only the dorsal portion of the perichordal tube of the intervertebral region becomes very thick the notochord is squeezed in the dorso-ventral direction. The thickened portion of the perichordal tube becomes cartilaginous. Subsequently the connective tissue cells pass in as in the foregoing case except that its direction is opposite to that of the other. Hence as the intervertebral cartilage becomes divided into a ball and a socket, the ball is at the anterior end of a vertebra and the socket at the posterior end, and the vertebra is thus of opisthocoelous type.

In *Xenopus lævis* the dorsal portion of the perichordal tube in the intervertebral region becomes very thick and eventually cartilaginous. Mention may be made in this connection that Ridewood (45) was unaware of the existence of the perichordal tube and he concluded therefore that the intervertebral body was formed by the extension of the dorsal arcualia. The ventral portion of the perichordal tube in the same region in fact, instead of remaining as a fibrous layer, is transformed into a rectangular cartilage. This piece of cartilage is connected laterally by means of a fibrous tissue with the upper cartilaginous

portion of the perichordal tube. The same cartilaginous piece is not metamerically arranged but continues along the vertebral column both in the vertebral as well as in the intervertebral regions. It eventually degenerates completely.

At the anterior region of the urostyle there are present on the two dorso-lateral corners of the perichordal tube external to the notochord, the dorsal arcualia and on the ventral side the hypochordal cartilage. From Geganbaur to Schauinsland, every worker had the idea that there were two dorso-lateral cartilages forming the dorsal arcualia, and a ventral arcualia representing the hæmal arch, along the entire length of the vertebral column. The descriptions of the formation of the vertebral column given by the above authors, could be applicable to some extent to the structure of the anterior portion of the urostyle, but not to trunk vertebræ ahead of it. Thus, perforce, one is inclined to ask whether these workers really took the sections from the trunk vertebræ, or were content with cutting only the Urostyle portion. In fact, the two figures given by Schwegmann, one for the trunk vertebræ, and the other for the urostyle, resemble, in a curious way, each other so closely that one fails to detect any difference between them except in size.

In the anterior region of the urostyle there are two pairs of dorsal arcualia; hypochordal cartilage also starts from the anterior limit of the urostyle and continues up to its posterior end. The posterior portion of the urostyle is bulky and there is no neural arch or cartilaginous dorsal arcualia at that end. The spinal cord in this portion is enveloped by connective tissue arches. At an advanced stage of the embryo, the hypochordal cartilage is pushed upwards, crushing the notochord. The perichordal tube by this time becomes cartilaginous.

The urostyle of *Bombinator* possesses an articulation with the ninth vertebra as in the other two examples. The ninth vertebra here, is of an·opisthocoelous type like other vertebræ. In the case of *Xenopus*, however, the urostyle is fused with the ninth vertebra. What Ridewood regarded as a hypochordal cartilage, extending from the atlas up to the end of the urostyle, is not homologous with the said structure in other species. It has already been proved that the aforesaid structure is a part of the perichordal tube. Ridewood (45) reports another ridge-like cartilaginous structure, situated below the so-called hypochord. This ridge-like structure is the true hypochord. I (29) have traced its development up to the adult form, and have found that what Ridewood calls hypochord proper, is nothing but a part of the perichordal tube, which ultimately degenerates. The hypochord (Ridewood's so-called ridge of the hypochord) persists. In the anterior portion of the urostyle it fuses with the dorsal arcualia crushing the notochord entirely.

According to Gegenbaur (13) a reptilian vertebral column starts with the formation of a cartilaginous tube round the notochord, which is continuous with the cartilaginous neural arches. The latter are placed in the vertebral region, and in these regions ossification sets in very early, while the notochord remains relatively unconstricted. In the intervertebral region the cartilage becomes thickened, as in Amphibia, and generally constricts the notochord. The cartilage in each of the intervertebral regions soon becomes divided into two parts which form the articular facets for two consecutive vertebræ.

Schauinsland (46), who worked on *Sphenodon*, has stated with regard to the development of the vertebral centrum, that, as soon as the sclerotomic cells have been liberated from the ventro-median corner of the mesodermal somite, they begin to spread along their medial part, and aggregate on both the right as well as the left sides of the notochordal sheaths. Later, these sclerotomic cells extend on the dorsal as well as the ventral surfaces forming a complete ring round the notochordal sheaths. The investing ring is known as the perichordal sheath. The perichordal sheath, which is very thin in reptiles, has been called by old authors like Goette (17), as *chorda sheath*. In the beginning the perichordal sheath has uniform diameter, and later (corresponding to the middle of each myotome) it becomes thickened, forming the intervertebral bodies. The perichordal sheath situated between the two consecutive thickened rings of intervertebral body is very thin forming an hour-glass. The middle portion of the hour-glass-shaped body thus formed represents the primary centrum which becomes surrounded by the rudiments of the arches arising from the sclerotome. The dorsal part of the rudiments of the neural arches envelops the spinal cord from the two sides and on chondrification forms the neural arch proper. The basal portion of the neural arch surrounds the primary centrum forming a secondary centrum.

Our investigation regarding the development of the vertebral centrum of Reptilia gives quite a different story altogether. In each reptilian vertebral column there is a neurocentral suture near the base of each basidorsal, and this is a unique structure and a speciality of the class Reptilia.

We know, that, in the case of *Rana temporaria*, the diapophysis (or transverse process) arises higher up from the lateral side of the basidorsal. In *Triton vulgaris*, the rib-bearing process is nothing but the diapophysis, and is located at the middle height of the lateral side of the basidorsal. In a lower Urodela, such as *Necturus maculatus*, the rib-bearing process is a latero-downward process situated almost at the end of the basidorsal. So we see that the diapophysis (or transverse process) is variable in its position in reference to the height of the lateral limb of the basidorsal, i.e. of the neural arch. The so-called suture in all reptilian vertebral column, therefore,

is equivalent to the diapophysis, being situated at the base of the basidorsal proper. In Lacertilia, such as *Gecko verticillatus* and *Calotes versicolor*, I have found for the first time, a lateral projection from this so-called suture with which the rib is articulated. The details of these structures I shall deal with at a later stage when I shall speak about the arches, the rib-bearing process and the rib.

Now the question is, that if the neurocentral suture is the real rib-bearing process, what should be the base of the basidorsal that has been reported by the previous workers? The answer is, that the latter is a part of the perichordal tube and has no separate existence. We have found that in all reptiles, after the formation of the notochord and its sheaths, the sclerotomic cells first form a ring round the notochord in each anterior half of the sclerotome. These rings are the perichordal rings. At a later stage the interspaces corresponding to each posterior half of the sclerotome have been filled up by the loose sclerotomic cells forming a complete tube which may be called the perichordal tube. In the mean time corresponding to each posterior half of the sclerotome there forms in addition, a dorsolateral aggregation which ultimately forms the basidorsal. At a later stage we find that the cells of the basidorsal stay in a procartilaginous stage and the whole of the perichordal tube still remains in a fibrous condition. At this time the sclerotomic cells actually get in between the base of basidorsal and the thick fibrous tissue of the perichordal tube. In a stage older than this we find that the fibrous tissue of the perichordal tube laid outside the notochrodal tube is differentiated only in the vertebral regions into two layers, viz., an inner and an outer. In the intervertebral regions the perichordal tube remains in the fibrous condition for a considerable time. The outer layer of the perichordal tube in the vertebral regions later becomes cartilaginous, while the inner layer persists as fibrous. It is this inner fibrous layer which every previous worker has identified as the perichordal tube, and the outer cartilaginous layer as the base of the basidorsal. Thus the erroneous idea of the formation of the vertebral centrum by the base of the arches has crept in.

A comparison of the two stages, viz., one before the chondrification sets in, and the other after completion of the chondrification, will show that the fibrous perichordal tube in the earlier stage is thicker in cross section than that of the later stage, the reason being, that in the first case we see the whole of the perichordal tube whereas in the later case, the inner portion only is seen, its remaining outer portion having become cartilaginous. This cartilaginous portion was mistaken by the previous workers as the base of the basidorsal.

Schauinsland (46) has given two figures of the transverse sections of *Sphenodon*, representing two stages; and an examina-

tion of his figures clearly shows that his interpretations of these structures were wrong. The perichordal tube of the earlier stage is thicker than the perichordal tube of the later stage, although the sections are of the same magnification. We have selected as representatives of Ophidia, *Tropidonotus stolatus* and *Naja naja*. I have found in collaboration with Chatterjee (34), that in each centrum there is a membraneous bone arch in the anterior, a cartilaginous basidorsal in the middle and a membrane bone arch in the posterior zone. The so-called suture which really represents the diapophysis is present not only at the base of the basidorsals but also at the anterior and posterior extremities of the centrum.

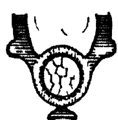
The condition of Chelonia is almost like that of Ophidia. As an example of this group I, in collaboration with Mukherjee (35), have worked on the Chelonia *Chrysemys marginata*.

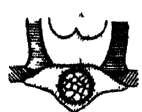
As an example of Crocodilia I have selected *Alligator missipiensis*, in which the condition is identical to that of Lacertilia with the difference that the membrane arches are absent.

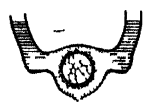
Piiper (41) has recently recorded that in Aves, there is a continuous perichordal tube outside the notochordal sheaths. Both the upper (dorsal) and lower (ventral) arches are situated towards the anterior end of the vertebra. The remaining portion of the tube has, in addition, the interdorsal cartilaginous arch at its dorso-lateral corners, the ventral, as well as the mid-dorsal sides of this portion of the perichordal tube being left unprotected. At the extreme end of the vertebra, the perichordal tube is enveloped by two consecutive rings—the anterior and posterior interventrals. From the posterior interventrals, the intervertebral ligament is derived.

According to my investigation on the vertebral column of the common fowl, the base of the neural arch does not meet the base of the hæmal arch. As a matter of fact there is present only the connective tissue layer representing the basiventralia just as in the thoracic vertebra of the frog. I have not found a single instance where the arch contributes towards the formation of the centrum. What Piiper indicates as the connecting piece of the bases of the basidorsal on the ventral side of the perichordal tube represents, in my opinion, the outer perichordal tube, as in Reptilia. Mention may also be made that Piiper has shown the intercentrum as quite distinct and different from the basiventralia, but most authors (Gadow and others) conclude that the intercentrum is not a separate element but represents the united basiventralia. The middle portion of the vertebra is shown by Piiper as very thin and it seems to us to be due to the fact, that it is made up of thin perichordal tube alone. Our observations show that however thin it is, this ring represents both the outer as well as inner perichordal rings. In the intervertebral portion, there aggregates three consecutive connective tissue bands exterior to the fibrous perichordal tube exactly

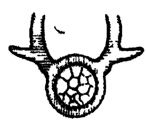


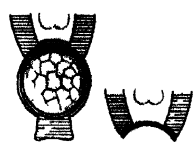
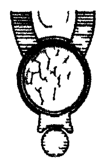


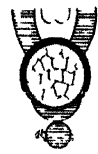


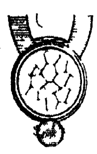


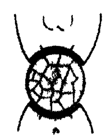


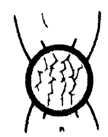


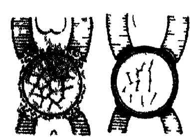















EVOLUTION OF CENTRUM

By courtesy of Current Science

like the intervertebral elements of the Teleostean fishes. The middle band is responsible for the formation of the intervertebral ligament. So Piiper's anterior and posterior interventrals are really the anterior and posterior intervertebral bands made up of migratory connective tissue cells.

Another point in favour of the view that the basiventralia do not take part in the formation of the centrum, is that in the anterior cervical vertebræ, the intercentra are present and these are recognized to be formed by the union of the basiventralia elements. If the basiventrals help in the formation of the centrum and remain thus occupied one may ask wherefrom do the united basiventralia come.

In a recent paper on the development of the vertebral column of mouse, Dawes (3) has shown that the centrum is formed by a perichordal tube laid outside the notochordal sheaths; and external to this, the basiventralia come to form an outermost ring of the centrum. In the intervertebral region, the interventrals assume 'U'-shape, and subsequently the two limbs of 'U' is bridged over by the interdorsals.

Regarding Mammalia, I have found, in collaboration with Das, that in *Talpa* the centrum has an outer as well as an inner perichordal layer in the vertebral region, as in the other two groups, viz., Reptilia and Aves. Although many workers have worked on the development of the vertebral column of mammals, none gives the detailed description of the caudal region of any type. I have already stated that Dawes showed that the centrum was formed mainly by the interdorsals and basiventrals; but as he confined his investigations only to cervical, thoracic, and lumbar vertebræ, he failed to detect that basiventralia in the trunk region of Mammals remained in a connective tissue stage. It is only in the caudal vertebræ that the cartilaginous 'V'-shaped hæmal arch occurs and the centrum of this region is exactly like that of the trunk region. In the caudal vertebræ there cannot be two sets of basiventralia, one to form the centrum and the other to form the 'V'-shaped hæmal arch. The 'V'-shaped arch has in fact three elements—two basiventrals and a midventral piece, the infraventral (Plate 2).

Formation of the Arches both Upper and Lower.

In all Vertebrata the neural arch protects the spinal cord. In Elasmobranch the neural arch is formed by the cartilaginous basidorsals which sit at the dorso-lateral corners of the notochordal sheaths, leaving, however, enough space at the base to allow the skeletogenous cells to enter inside the fibrous sheaths of the notochord. The basidorsals of either side meet above in the mid-dorsal line, and there is a third piece of cartilage to complete the neural arch. This third piece is called the

supradorsal, from the top of which, in these instances, there develops a dorsal spine. Throughout the whole of the vertebral column the space between the neural arch of one vertebra and the neural arch of the next is filled up by an arch-like structure called intercalary. On the ventral side, there are two ventro-lateral basiventrals which also like the basidorsals, do not arise directly from the notochordal sheaths but there is a narrow space between them for the entry of the skeletogenous cells into the fibrous sheaths so as to form the centrum. There are ventral intercalaries just as the dorsal ones.

The hæmal arch encloses the caudal vein and the dorsal aorta. In the anterior region of the vertebral column, the hæmal arch consists of two basiventrals which do not meet to complete the arch. In the caudal region the ventral inter-calaries are greatly reduced or absent.

In Teleost, the cartilaginous basidorsals do not sit directly on the dorso-lateral corners of the sheaths of the notochord but a little away from it, so that just outside the notochordal sheaths the skeletogenous cells aggregate round the latter forming an outer jacket which is known as the perichordal tube. In some cases the outer surface of perichordal tube is depressed in to form pits to lodge the bent ends of the cartilaginous basi-dorsals and this happens when the perichordal tube is in the state of mesenchymatous condition. So that, in the adult condition the neural arch bases look as if they are sunk in within a cavity or pit in the perichordal tube which forms the main part of the centrum. In case of Teleost, the neural arch has no supradorsal like the Elasmobranch but the basidorsals of either side meet at the mid-dorsal line, and from this a long spine is projected towards the dorsal direction. Towards the dorsal extremity within the neural canal there are two pieces of carti-lage placed side by side which are called by some workers as supradorsals. Both the neural and the hæmal arches lie at the anterior end of the centrum, so that the rest of the centrum has no cartilaginous or osseous structures to give protection to the spinal cord or the caudal vein and dorsal aorta.

The condition of the neural and hæmal arches in different orders of Amphibia varies, but the broad principle is the same in all cases. According to the opinion of the previous authors in a higher Urodela such as *Triton vulgaris*, the neural arch is made up of two cartilaginous basidorsals of either side which eventually meet at the mid-dorsal line to complete the neural arch.

Gadow (9) has recorded that the bases of the neural or the hæmal arch, principally contribute to the formation of the centrum. I (28, 38) have already shown in my papers on *Triton vulgaris* and *Necturus maculatus*, that the centrum is independently formed, and the arches have nothing to do with the formation of the centrum. The arches are structures super-

imposed on the perichordal tube from which alone the centrum is derived.

In each vertebra, the cartilaginous basidorsals are generally situated in the middle of the centrum, and in the portion immediately preceding and following the cartilaginous arch, the spinal cord is protected by the corresponding anterior and posterior connective tissue arches. The cartilaginous basidorsals are situated in such a manner that this arch is deflected gradually towards the posterior end and tilts over the top of the connective tissue arch next to it. One point that I like to mention here is that the connective tissue arches in the case of *Triton vulgaris* have three definite elements, that is, two perpendicular side-pillars and a horizontal roof piece resting on side-pillars, with lateral edges projecting.

According to the previous workers, the basidorsals of either side meet at the mid-dorsal position to complete the neural arch, but I have shown definitely in the case of *Triton* as well as in *Necturus* that there is a third piece of cartilage the supradorsal, the existence of which was emphatically denied by Gadow (9). The existence of the connective tissue arches reported for the first time by me was not known then. These connective tissue arches become osseous without undergoing through the stage of chondrification. The arches should now be called as the anterior and the posterior membrane bone arches. They are different from the intercalary arch in Elasmobranch. From the middle of the roof of the anterior membrane bone arch a long spine arises in *Triton vulgaris*, the existence of which was overlooked by Gadow.

Between the two consecutive vertebræ that is at the intervertebral region, the spinal cord is protected by a fibrous layer on the lateral sides and by the supradorsal of the preceding vertebra on the top. The edges of the supradorsal form the post-zygapophysis. The lateral fibrous layers of the intervertebral region remain as such throughout life, and can be seen even in an adult specimen.

I should now direct your attention to the degeneration of the cartilaginous arches not noted by previous workers. The basidorsal as such does not degenerate entirely, but the cartilaginous cells composing it, together with the inner perichondrial layer degenerate, leaving the outer perichondrial layer intact. The cartilage of the supradorsal element does not degenerate, so that in the adult condition it becomes a massive structure. The spinal cord hence is protected within the limit of the vertebra, by the anterior membrane bone arch, the outer perichondrial layer which also becomes osseous, and by the posterior membrane bone arch. When the basidorsal was in cartilaginous condition, its thickness was much more than that of the membrane bone or the connective tissue arches; but after the degeneration, it becomes just the reverse. In lower

Urodela such as *Necturus maculatus*, an identical condition has also been found by us with regard to the constituent parts of the neural arch. The striking difference is that the basidorsal and the connective tissue arches look alike but these instead of being a squarish arch are roundish in shape and a little bigger than the outer perichondrial element of the cartilaginous arch.

In the hæmal arch element of *Triton vulgaris* in the thoracic region, we generally get a thin osseous rod which at one end is connected with the centrum and its other end attached to the ventral bond of the rib. At the portion where the anterior or the posterior connective tissue arches are present, an osseous rod also exists which looks like a horizontal wing-like structure.

Regarding the hæmal arch element of the tail the previous workers were of opinion that the cartilaginous basiventrals sit directly on the sheath of the notochord and their free ends eventually meet.

Each hæmal arch according to our observations is formed (i) by the anterior connective tissue arch which ultimately becomes a membrane bone, (ii) by a cartilaginous arch which is made up of basiventrals of either side, and (iii) by a posterior connective tissue arch; all these arches being arranged in a linear series one after the other. Infraventral like the supradorsal completes the cartilaginous arch. From the middle of the roof of the anterior connective tissue arch, a ventral spine arises. In the thoracic vertebra of *Necturus maculatus* (lower Urodela) the basiventral is in the form of a cartilaginous transverse rod arising from the side of the centrum at the middle of its height. The rod at a little distance from its point of origin meets with the diapophysis and continues as the parapophysis with which the rib articulates. Similarly at the anterior and posterior ends of the centrum of the same region, wing-like processes are present and these represent respectively the anterior and posterior connective tissue arches. These connective tissue rods or processes were not mentioned by the previous workers.

Regarding the development of the neural arch of Anura, the previous workers are of opinion that the two cartilaginous basidorsals of either side eventually meet mid-dorsally to complete the arch and the vertebral centrum was derived principally from the bases of this arch.

I (29) have shown definitely that in the formation of the centrum, the arch plays no part, the perichordal tube alone being responsible for the formation of the centrum.

As regards the ventral arch, the previous workers were of opinion that an united basiventralia or hypochordal was present in all vertebræ from the first vertebra to the urostyle. I have pointed out that the thoracic vertebræ of frog or toad do not possess the hypochordal element, the urostyle only or the fused vertebræ of the posterior end of the vertebral column

possessing alone this structure. In the vertebral column of *Xenopus*, Ridewood (45) by mistake, supported the statement of Schwegmann (47) regarding the presence of the hypochordal element in the whole of the vertebral column. The real fact is that the so-called hypochordal which is present in the larval state of *Xenopus* along the entire length of the column, is really a part and parcel of the perichordal tube which ultimately suffers degeneration.

In the tail region of Anura in the tadpole stage, the spinal cord is protected only by the connective tissue arches which ultimately degenerate and become absorbed during the metamorphosis of the tadpole.

Schauinsland (46) has shown that in Rhynchocephalia the centrum is formed by the base of the cartilaginous basidorsal that envelops the perichordal tube. I have already told you that in all Reptilia the cartilaginous basidorsal has no such separate base as the one Schauinsland described. The so-called base of the basidorsal is really a portion of the outer perichordal tube on the dorso-lateral corners of which, the cartilaginous basidorsals come to rest. The perichordal tube in the vertebral regions is arranged into two concentric rings—the inner one remaining fibrous for a long time and the outer one soon turning cartilaginous. It is this fibrous inner layer that almost every worker, including Schauinsland, has indicated as the perichordal tube and the outer cartilaginous layer was shown as the base of the basidorsal.

In all Reptilia intervening between the base and the limb of basidorsal proper, there appears to be a suture that really represents the diapophysis referred to before. This is a unique structure in the Vertebrata.

Most authors stated that in Lacertilia the neural arch is formed by the basidorsals of either side which eventually meet at the mid-dorsal line; but I find that the basidorsals together with the supradorsal are responsible for the formation of the neural arch as in the Urodela. From the supradorsal, the neural spine arises as in the other case. Besides these, a remnant of the connective tissue arch is present interposed between the two successive cartilaginous basidorsals. The connective tissue element without passing through the stage of chondrification becomes osseous. This does not form a complete arch as in *Triton vulgaris*, but the roofing is made up of cartilaginous element belonging to the previous vertebra and transposed to this. In the precaudal vertebræ there is a rod of cartilage attached to the posterior region of each vertebral centrum. This rod of cartilage is called the intercentrum or the united basiventralia and it is located at the extreme end of the centrum.

In the tail vertebræ the neural arch is exactly like that of the precaudal vertebræ. But the hæmal arch element is attached to the extreme posterior end of a centrum and appa-

rently looks as if it is attached to the intervertebral element. Each hæmal arch or chevron bone as it is called, is made up of two basiventrals with a third piece namely the infraventral. An important point worth noting is that the vertebra of the tail region of Lacertilia has a fibrous layer running right through the middle zone of each vertebra; owing to the existence of this fibrous band, a weak spot in the centrum as well as in the arch arises rendering possible the caudal autotomy.

I have shown in collaboration with Chatterjee (34) that in Ophidia there is not only the supradorsal at the mid-dorsal position of the cartilaginous arch as in *Triton vulgaris*, but there are also two connective tissue arches respectively placed anteriorly and posteriorly to the cartilaginous arch. The anterior connective tissue arch bears a dorsal spine which is very prominent. The connective tissue arches become osseous without passing through the stage of chondrification as in Urodela. Between the anterior connective tissue arch of one vertebra and the posterior connective tissue arch of the previous vertebra, there is no fibrous layer corresponding to that of the *Triton vulgaris*, but the first arch articulates with the second at two extra points. These are the zygosphene and zygantrum to which I shall refer later.

In the tail vertebræ there are cartilaginous arches composed of basiventral elements but the arch itself is not a complete one in the sense that the side pillars alone remain there without a floor. The free ends of the pillars continue as connective tissue rods. These connective tissue rods become osseous without passing through the stage of chondrification, so that in the adult vertebra there is a thin membrane bone element continuous with the free end of the incomplete hæmal arch. The latter has a stout osseous base directly derived from the cartilaginous arch element itself and this base must not be confused with the so-called base of the basidorsal.

In Chelonia the neural arch of the cervical vertebræ has been noted by the previous workers to be just like the neural arches of other Reptilia. I have shown in collaboration with Mukherjee (35) that each vertebra has in addition to the cartilaginous arch in the middle, the anterior and posterior connective tissue arches which ultimately become membrane bone arches. The cartilaginous arch unlike that in other Reptilia has no third element, i.e., the supradorsal is absent. In the thoracic region the basidorsals (cartilaginous arches) stand on the centrum like perpendicular pillars with a third piece of cartilage as the roof, on which the carapace rests. Here, there is no trace of a mid-dorsal spine. These cartilaginous arches are located in the beginning, at the middle of a centrum, but at a later stage these are shifted towards the anterior end of a centrum, but instead of deflecting backwards they are deflected forwards towards the preceding vertebra. Goette (17) has stated that the

arches at this region are placed at the intervertebral region, i.e., between two consecutive centra but that is not the fact. The rest of the centrum has connective tissue arch which is really two in number, one being placed just after the cartilaginous arch and this is the posterior connective tissue arch; while at the extreme end the other connective tissue arch is the anterior connective tissue arch of the next vertebra that has come to lie here due to forward shifting; the spinal nerve comes out through these connective tissue arches corresponding to the middle of the centrum. In the tail region the neural arch is like that of the cervical vertebra in having the supradorsal element. The hæmal arch in most cases is like that of Lacertilia, but specimens with short tail, have no hæmal arch at all.

In the vertebral column of Crocodilia the neural arch is made up of cartilaginous basidorsals with a supradorsal at the mid-dorsal position. The hæmal arch in the tail region is exactly like that of the Lacertilia but in the trunk region it is made up of mesenchymatous tissue which remains as such throughout life.

Piiper (41) recently has stated that in Aves the neural arch is made up of two elements: (i) the basidorsals of either side located at the anterior end of the centrum with a supradorsal on the top, and (ii) interdorsals completing the neural arch. Piiper's above conclusion has not been confirmed by subsequent workers. Dawes (3) in his recent paper on Mammalian vertebral column, concludes, however, that the neural arch is entirely made up of basidorsal of either side with the supradorsal at the top to complete it. The difference in the character and composition of nuclei at the formative stage of the vertebral column on which Piiper bases his conclusion is rather difficult for me to support in the example of the common fowl investigated by me.

Piiper (41) has also mentioned that in Aves each vertebra has basiventralia connected with the bases of the basidorsals so as to form the centrum. Dawes (3) has stated the same thing in mouse and supported Piiper. Dawes did not work out the tail region and one could see that in the caudal vertebræ investigated by us, a hæmal arch is composed of three elements, viz., two basiventrals one on each side with a third median piece called the infraventral. If we accept Dawes' view then there would be two hæmal arch elements, one forming the centrum and the other forming the hæmal arch proper, but this is not possible. In the thoracic region the presence of basiventralia in the form of mesenchyme, escaped the notice of Dawes.

Formation of the Ribs and the Rib-bearing Processes.

Ribs are of two kinds: (1) upper or dorsal rib, and (2) lower or pleural rib. Both kinds originally were connected proximally

with the basiventral. Gagenbaur (13) stated that they were derived from the axial skeleton, while Hasse (21) and Emelianoff (4) considered that they were independent structures which acquired connexions with the axial skeleton. In Elasmobranch the ribs are of dorsal type. In lower Teleostomes such as *Amia calva*, the ribs are of pleural type. In higher Teleosts both types are present. The upper ribs are usually attached by ligaments to the sides of the centrum.

Gray (20) has stated that in Urodela such as *Triton vulgaris*, the rib-attachment is effected as in Amniota by the inward growth of the rib passing beneath the vertebral artery so as to reach the centrum. Such a structure, therefore, is exactly homologous with the capitulum or the head of the rib. The rib-bearer or diapophysis joins, however, not only the dorsal fork of the rib (i.e. tubercle) but also establishes secondarily an osseous connection with the neck of the capitulum above the vertebral artery. This mode was mistaken by the previous authors for the true capitulum.

I agree with Gray with regard to the formation of the rib and the rib-bearing process although certain structures associated with them had not been mentioned by him. Attached to the anterior and the posterior connnective tissue arches, are two lateral connective tissue rib-bearing processes. These arches have basiventralia composed of connective tissue.

Goeppert (14, 15) thought that there was a hæmal arch element (basal stump) attached to the lateral sides of the centrum of a lower Urodela like *Necturus maculatus*. Each hæmal arch from the middle of its length, sends off a dorsal process which he called the rib-bearer. This passes up dorsally to the neural arch and laterally to the vertebral artery and then continues dorso-caudally over the surface of the arch. The rib-bearer is separated from the cartilaginous arch primarily by a connective tissue which subsequently becomes osseous. Further off from the side of the rib-bearer, the basal stump continues horizontally and the rib is a mere prolongation of this element. Still more lateral to this, the rib assumes its distinct form and dorsal process of this extends towards the vertebra and becomes the dorsal head of the rib. This dorsal process is prolonged into a ligament which is attached by its other end to a mass of bony tissue developed on the outer side of the rib-bearer.

According to Gamble (12) the mesenchymatous condition of the rib (which he calls as its proton) and the rib-bearer are made up of a large number of cells which aggregate in contrast to the proton of parapophysis. The first cartilage to appear is the basal stump. Later, the parapophysis is formed as a dorso-lateral outgrowth. The first cartilage of the rib appears distally and later mesially. The first cartilage of the rib-bearer appears at the side of the neural arch. Next, this grows ventrally and fuses with the distal end of the parapophysis, and is

prolonged dorso-caudally over the outer surface of the neural arch. The proximal end of the rib is relatively high in the second and third vertebræ, i.e., it is on a level with the base of the neural arch. The parapophysis of the vertebræ in which the rib is high, does not lie in a horizontal plane, but extends dorso-laterally and approaches the rib-bearer. The rib-bearer and the parapophysis do not fuse until relatively late, while the rib becomes attached to the rib-bearer, before the rib-bearer and the parapophysis could come together. In the second and third vertebræ, the capitular as well as tubercular heads of the rib become attached to the corresponding processes of the rib-bearer. In these vertebræ, the parapophysis takes no direct part in the formation of the rib-attachment-apparatus. Here, the rib is an independent element from the standpoint of its origin, and the connection with the basal stump is effected at a later stage. In the trunk vertebræ the rib is on a level with the middle of the centrum. Here, the capitular head of the rib is attached to the parapophysis, and the tubercular head makes no connection with any process of the rib-bearer. The rib-bearer fuses with the distal end of the parapophysis and as growth takes place the distal end of the parapophysis extends laterally past this point of union. Between the dorsal and ventral cartilaginous rods as well as the transverse processes and the two heads of the rib in the second and third vertebræ, procartilaginous cells persist which by proliferation bring about the elongation of the transverse processes. In the trunk vertebræ the head of the rib has no cartilaginous connection with the rib-bearer, therefore this provision just referred to, is necessary only in the case of the parapophysis.

Regardir g the development of the rib-bearing process and the rib neither Goeppert's (14, 15) nor Gamble's (12) statement is correct. According to my investigation carried on in collaboration with Das (38), I found that in a trunk vertebra the first chondrification that takes place with regard to the formation of the rib and its associates, gives rise to the formation of the basal stump which occurs on the lateral side of the centrum at the middle height of the latter. Soon after this a separate centre of chondrification starts up from the outer side of the basidorsal almost from its base and proceeds in the ventral direction to meet the horizontal basal stump. This downward piece of cartilage is the rib-bearing process or the diapophysis. The vertebral artery lies within the space dorso-laterally enclosed by the rib-bearing process and ventrally by the basal stump. Both Goeppert and Gamble have stated that the rib-bearing process is situated on the side of the basidorsal and it attains towards the dorsal side a considerable height. As a matter of fact in a trunk vertebra barring the first four, the rib-bearing process does not proceed along the side of the basidorsal towards the dorsal side. In the mean time another chondri-

fication starts at the free end of the basal stump. This is a rod-like structure representing the ventral fork of the rib. At the anterior portion of the vertebra where the anterior connective tissue arch is present, connective tissue cells aggregate on the lateral side of the centrum and on the same level as the basal stump. The same thing happens towards the posterior region of the vertebra. The two connective tissue aggregations on the two lateral sides of the basal stump are responsible for the formation of these horizontal wing-like osseous processes, which Wilder (48) has referred to in his description of the adult skeleton of *Necturus maculatus*.

The connective tissue aggregations in question becomes osseous as a membrane bone without passing through the stage of chondrification. At the posterior portion of the vertebra in the region where the posterior connective tissue arch is present another condensation of connective tissue takes place and this condensation is at the dorso-lateral sides of the arch, at a higher level than the upper end of the rib-bearer. From these condensations a thin band of connective tissue cells is produced towards ventro-lateral side This condensation of connective tissue cells at the dorso-lateral sides of the posterior connective tissue arch in each vertebra, becomes osseous as membrane bone, without passing through the stage of chondrification forming thus the diapophysis of the posterior membrane bone arch The projected ventro-lateral bands of connective tissue articulate with the rod-like rib a little below the tip, forming the dorsal fork. So that the dorsal fork of the rib of the trunk vertebra other than the second, third, and fourth is a membrane bone.

We should like to point out that the connective tissue by means of which the membrane bone diapophysis articulates with the cartilaginous rod of the rib, is never wholly converted into bone, but only that portion of it becomes membrane bone which forms the dorsal fork of the rib Between the dorsal membrane bone fork of the rib and the membrane bone diapophysis, the connective tissue band becomes a ligament. At a later stage all the cartilag'nous structures of the rib and its associates become osseous Subsequently the space between the membrane bone diapophysis on the dorsal side and the osseous basal stump at the ventral side, which was filled up by loose connective tissue, also becomes a thin sheet of vertical membrane bone. Wilder (48) in his description has referred to this and Gamble (12) has shown it as merged in with the rib-bearing process. In the vertebræ from second to fourth the cartilaginous rib-bearer starts a little higher in level, and it is formed along the side of the basidorsal. In the meantime the cartilaginous basal stump goes upwards to meet the lower top of the rib-bearing process. The vertebral artery lies within the curvature of the basal stump. The rib-bearer sends side

processes, one from the dorsal portion, a little downwards from the dorsal extremity and the other from the point of union of the rib bearer and the basal stump. Really speaking the ventral projection is the prolongation of the basal stump. The rib has two forked processes which are articulated with the two dorso-lateral projections just mentioned. The ventral fork of the rib is the capitulum and dorsal fork is the tuberculum. These two forks meet together to form the base of the rib. We like to point out here that Gamble (12) is wrong in saying that the rib is an independent structure and has nothing to do with the basal stump or parapophysis. As a matter of fact the basal stump articulates first with the rib-bearer and from the point of this union the basal stump is prolonged as a lateral outgrowth. The posterior membrane bone arch has the membrane bone diapophysis which can be found as a projection on the top of the cartilaginous diapophysis. So in these vertebræ when ossification takes place the two forks become stout rods of bone articulating with the two rods, one with the dorsal diapophysis and the other with the ventral parapophysis.

In *Rana temporaria* and *Bufo melanostictus* diapophyses are present on the two dorso-lateral sides of the cartilaginous neural arch but distinct ribs are absent. I (29), however, noted the presence of ribs at the free ends of the diapophyses of 2nd, 3rd, and 4th vertebræ in the cases of *Bombinator igneus* and *Xenopus lævis* representing Anura. Ridewood (45) is mistaken when he says that in *Xenopus* the 2nd, 3rd, and 4th vertebræ have no diapophyses. As a matter of fact, there are small diapophyses quite distinct from the ribs, and even the suture for the articulation could be easily detected. Ridewood could not detect this simply because he did not cut sections, but only had examined whole mounts of the larval stages ; and he himself has admitted that his enquiry makes no pretence to completeness.

I have already told you that in Reptilia there is a suture-like structure at the base of each basidorsal proper, which is really the diapophysis, and with it or its protuberance as in *Gecko verticillatus*, the rib is articulated. In Ophidia there are big lateral projections from the so-called suture of the neural arch with which the ribs are articulated. These projections are quite prominent even in the adult skeleton. At the base of the tail in Reptilia in general the rib, which is an independent structure, becomes fused with the diapophysis (suture-like structure) and in the adult condition looks like a big transverse process. In case of Chelonia in the thoracic region the ribs are fused with the dermal lateral plates of the carapace.

In Aves and Mammalia the ribs have generally two facets, the capitulum and the tuberculum. The capitulum is articulated with the centrum the ventral portion of which is provided with the basiventralia existing in a mesenchymatous

condition, while the tuberculum is articulated with the diapophysis of the neural arch. In the caudal vertebræ there are no ribs in both classes.

Formation of the articulations.

In the formations of articulations in the vertebral column in the Vertebrate series we generally get the following :—

1. Zygapophyses—pre- and post-.
2. Zygosphene and zygantrum in Ophidia.
3. Articulation of the ribs with the rib-bearers of the diapophyses.
4. Articulation of the centra of the vertebræ.

The pre- and post-zygapophyses are found between the two consecutive cartilaginous neural arches in almost all the different classes of Vertebrata except Elasmobranchs where there are no articular processes between the arches. In Teleostean fish where there are big gaps between two consecutive neural arches, this sort of pre- and post-zygapophyses cannot confer rigidity. In these fishes, mesenchymatous cells aggregate on the two dorso-lateral aspects of the extreme posterior surface of the vertebral centrum which curves upwards to meet the basidorsal of the next vertebra, but none has stated as to how they are actually formed of the two pieces, namely, the pre- and post-zygapophyses. The formation of zygapophyses has not been touched in this direction by Gadow, Schauinsland, Piiper, and Dawes. Miss Platt (42) who mainly worked on the development of the skull of *Necturus*, incidently said that the neural arches become connected with one another at their dorsal extremities by a pair of longitudinal bars of procartilage, which break up into two, so as to form articular facets. Miss Platt did not mention how it breaks up into two. All the other workers did not attempt the solution.

In all the cases investigated by me either independently or in collaboration with my students, we found that on the lateral aspect of the posterior portion of the backwardly projected supradorsal or where there is no separate supradorsal, on the mid-dorsal area of the basidorsals, two aggregations of sclerotomic cells exist. These aggregations of sclerotomic cells continue caudally to reach in a slanting manner the cartilaginous neural arch of the next vertebra. Eventually the elongated sclerotomic rod thus formed becomes procartilaginous. When this rod is in a procartilaginous stage, migratory connective tissue cells from the exterior enter and cut the procartilaginous rod into two. The direction of the migratory cells varies, sometimes it is straight, but in most cases it is curved. A synovial cavity is formed starting from the periphery towards the centre, within the track of the migratory cells. The recent workers like Piiper

(41) and Dawes (3) failed to mention the existence of these migratory cells.

I have already mentioned that in the Ophidia the anterior connective tissue arch joins with the posterior connective tissue arch of the previous vertebra, forming two points of articulation and, therefore, in a transverse section passing through the intervertebral portion, two additional dorso-lateral articulations are found which are called the zygosphene and the zygantrum respectively. Although in the intervertebral region of Ophidia, there is no fibrous layer like that of Urodela, the flexibility is still possible on account of the existence of these extra points of articulation. The zygosphene and zygantrum are actually formed when a strand of migratory mesenchymatous cells enter through the points of union of the anterior connective tissue arch with the posterior connective tissue arch of the previous vertebra. These connective tissue arches become osseous without passing through the stage of chondrification as membrane bones, and in between the two arches through which the migratory cells enter, a synovial cavity occurs splitting the line of migratory cells into two.

Cause of origin of different types of vertebræ.

In Vertebrata we generally find four forms of vertebræ, namely procoelous, opisthocoelous, amphicoelous, and heterocoelous. In case of fishes we get exclusively the amphicoelous form. Mammalian vertebræ are near approach to the amphicoelous type. In Amphibia and Reptilia all the types excepting the heterocoelous one occur; in Chelonia sometimes we get the first three forms even in one and the same individual. In Aves we get almost exclusively the heterocoelous form.

The importance of the inquiry as to the causes of the formation of different forms of vertebræ is self-evident as different forms of vertebræ furnish characters diagnostic and useful for classification.

Although Gegenbaur (13), Goette (16, 17), Gadow (9, 10, 11) and all other principal workers on the development of the vertebral column are of opinion that there is no basic principle in the mode of development of the vertebral column, we hold a different opinion. I (28, 29, 32, 33, 36, 37) have already shown that basic principle exists in the method of development and is the same everywhere. After the formation of the perichordal tube round the notochordal sheaths, the vertebral portions of it acquire connections with the dorsal arcualia (neural arches) which sit at the dorso-lateral corners outside the perichordal tube. The vertebral portions of the perichordal tube soon become cartilaginous whereas the intervertebral portions remain for a long time membraneous or procartilaginous. I (28, 29, 30, 32, 33, 36, 37) have already stated that through

these intervertebral zones of perichordal tube, the migratory connective tissue cells enter.

The migratory connective tissue cells normally enter through the intervertebral portions of the perichordal tube, the direction of in-flow being at right angles to the notochord and to the vertebral column. I believe that procoelous, opisthocoelous, amphicoelous, and heterocoelous conditions are produced by various types of movements of the embryos at the time when the migratory connective tissue cells enter actively the intervertebral zones of the perichordal tube.

We all know that the fry of fish progresses through water by the movement of the fins, keeping its body almost straight. The migratory connective tissue cells go in through the intervertebral portion, almost at right angles to the notochord. The migratory connective tissue cells are arranged side by side into three bands. The middle band is responsible for the formation of the intervertebral ligament. The two lateral bands of connective tissue cells which ultimately become cartilaginous, give rise to the formation of two surfaces of the centrum. In case of other classes where we get the amphicoelous vertebræ, the migratory connective tissue cells are arranged at right angles to the notochord. In case of Mammals only, instead of giving rise to an intervertebral ligament like that of a fish, the middle band of connective tissue cells is converted into a fibro-cartilaginous disc.

It has been observed that a tadpole moves through water oscillating the whole body except the head, in such a manner that the greatest degree of oscillation will be located at the free-end of the tail, in both clockwise and anticlockwise directions and thereby the course of migratory cells is changed with reference to the notochord, from the perpendicular direction to a curve, the concavity of which is directed towards the cephalic end; and the formation of a procoelous condition thus takes place. The formation of actual procoelous condition takes place when a split is formed as a synovial cavity within the zone of curvature formed by the migratory connective tissue cells which ultimately become cartilaginous. In case of Lacertilia, like *Calotes*, we could get the same sort of condition in the intervertebral regions. Similarly a rhythmic movement of the snake embryos is perceptible even from outside the egg-shell, which is rather soft and papery. The vertebræ of snakes are generally procoelous. It may be inferred from the mode of oscillation that the particular mode of movement of the snake and lizard embryos is responsible for the formation of this type of vertebra.

In the case of Newts which were reared in the laboratory, I observed that during their post-embryonic stage they move forward in the water by oscillation of their head ends, and the migratory cells in this case, therefore, pass in a curve the direc-

tion of which is opposite to that of the tadpole; thus an opisthocoelous condition arises as a synovial cavity is produced along the line of migratory connective tissue cells which split into two lines.

Confirmation of these views is obtained in Chelonia where the head and neck move in such a way as to give rise to an opisthocoelous condition, while the tail moves in a different direction so as to bring about a procoelous condition; and the middle region of the body, remaining stationary due to the early formation of the carapace, produces the amphicoelous condition.

The heterocoelous form occurring in most birds, is a modification of the procoelous type. Like the tadpole, the embryo of bird oscillates its body in clockwise and anticlockwise directions, while its head is kept in a so-called stationary condition. We will have to infer the mode of movement of the embryo where it is not perceptible, from the direction and the line of curvature pursued by the migratory connective tissue cells. An analogy may be drawn from that of the tadpole, where we can actually see that during this stage the forward movement is effected by the oscillation of the tail its head remaining stationary. An interesting point with regard to the formation of the heterocoelous vertebra, is that the migratory connective tissue cells instead of entering the intervertebral region in one band as in the case of the tadpole, enter the intervertebral region as three consecutive bands like those in the fry of fish. The middle band quickly becomes a ligament, whereas the two lateral bands eventually become procartilaginous. As in the tadpole, we get here a condyle and a socket formed from the two lateral bands, and in between the two, there forms a synovial cavity in which lies the intervertebral ligament. In order to accommodate this intervertebral ligament, the condyle has a depression on the top. The depression is also present in the socket, but it would not be so prominent as on the condyle for the simple reason that the socket itself is a depression or cavity. As the condyle moves against the socket in both clockwise and anticlockwise directions, with the ligament in between them, the depression of the condyle presents also a convex surface when viewed from the dorsoventral direction. Thus we get a heterocoelous saddle-shaped vertebra with socket in the anterior and a condyle at the posterior end, by the modification of the procoelous type.

In conclusion, we may say that those animals that oscillate their cephalic end during the embryonic stage when the migratory connective tissue cells are entering through the intervertebral zones of the perichordal tube, have opisthocoelous type and those that move their posterior portion of their body, keeping the anterior end in a so-called stationary condition, generally have a procoelous type, and when there is an inter-

vertebral ligament intervening between the ball and the socket of a procoelous vertebra we find a depression on the top of the ball of the centrum for accommodating the intervertebral ligament, and a heterocoelous vertebra is thus formed, while those that do not oscillate their body but keep it in a so-called stationary condition generally have amphicoelous vertebra.

SUMMARY AND CONCLUSION.

In summarizing the modes of development of the centra, I would like to point out that, however diverse the processes appear to be, the centra in the different classes have not been evolved one independent of the other as the various theories put forth by the previous authors suggest, but all the vertebrates have followed the same course of development, maintaining an unbroken continuity from one end of the vertebrate series to the other, quite in keeping with the Darwinian theory of gradual evolution.

In all vertebrates except in Elasmobranch, the perichordal tube alone gives rise to the formation of the centra. The arches or their bases do not take any primary part in the centrum formation, as assumed by previous authors, but acquire connection with the centra secondarily by coming to sit directly on the perichordal tube which was formed independent of the arch-elements. The perichordal tube, in all cases except in the Elasmobranchs, is formed by the aggregation of the skeletogenous layer around and outside the notochordal sheaths.

According to the manner of chondrification and ossification of the perichordal tube, condition having semblance to epichordal or perichordal type arises.

In Elasmobranch the centrum is formed by the chondrification of the sheath by the help of migratory skeletogenous mesenchymatous cells.

Starting from the Teleost in which the perichordal tube is converted into a bony ring distinct from the notochordal sheath, we can pass through the whole series of Amniota. In Anamnia, Herring forms an exception inasmuch as both the sheath and the perichordal tube ossify. In Amniota the perichordal tube in the vertebral region is converted primarily into two concentric rings, an inner and an outer.

Although the majority of vertebrates conform to the linear series with regard to the centrum formation, such types as *Amia* among Teleost, *Amblystoma* among Urodela, *Bombinator* and *Xenopus* among Anura, show deviations from this fundamental ground plan, as a result of adaptation to changed conditions of life.

The neural arch in Urodela is composed of a pair of cartilaginous arches called *basidorsalia* and a dorso-median plate called *supradorsal*. These arch elements are present in almost

all the vertebrate series. Thoracic and caudal vertebræ of Chelonia, Lacertilia, Ophidia, Crocodilia, Aves, and Mammalia retain the Urodelan condition. The Teleost, the Anura and the cervical vertebræ of Chelonia, however, differ from the above series in having no distinct supradorsal; and some Teleost, viz., Haddock is peculiar in having the basidorsal arch as membrane bone.

In Urodela, Ophidia and in the cervical and caudal vertebræ of Chelonia two additional arches are found associated with each centrum. Both these arches are in the beginning, composed of connective tissue, one being placed anterior, and the other posterior to the basidorsal. At a later stage owing to the ossification and fusion, these three separate arch elements lose their distinctness; therefore in an adult vertebra, a single neural arch appears to be present. The existence of these membrane bone arches was missed by the previous workers. Another point that was missed by the previous workers, is the degeneration of the cartilaginous cells which occur together with the inner perichondrial layer of the basidorsals of Urodela, because none of the previous workers traced the development beyond the stage of chondrification. By modification of the above condition such as the addition of anterior and posterior membrane bone arches in Urodela, Ophidia, and in cervical and caudal vertebræ of Chelonia, or of their displacement as in the thoracic vertebra of Chelonia, the seemingly diverse types of the neural arch have been evolved. The dorsal spine, in all cases except the thoracic vertebræ of Chelonia, is formed from the mid-dorsal roof of either the anterior connective tissue arch or from the supradorsal.

With regard to the lower arch of the vertebra, it may be said that this arch is composed like the basidorsal, of a pair of basiventralia and a median infraventral piece. This typical condition is found generally in the caudal vertebræ of Urodela, Reptilia, and Mammalia. Considerable modifications of this typical condition occur in different groups and also in different regions of the vertebral column. In the trunk region of the Elasmobranchs and in some of the Teleosts, a pair of basiventralia exist as divaricated transverse rods. In Urodela, the rods are very thin and membraneous except in *Necturus* where they are cartilaginous. In those groups where the basiventral element persists in the membraneous condition throughout life, the previous workers by mistake have stated that the basiventral element fuses with the other elements to form the centrum such as in Anura, Aves, and Mammalia. In some cases the basiventral elements of either side fuse into one piece to form, either the intercentrum as in Lacertilia, Ophidia, and Aves, or the hypochordal structure as in Teleost and in the urostyle region of Anura. In those animals where the dorsal arcualia are made up of two membrane arches in addition to

the cartilaginous arch, the ventral arcualia show similar composition in being made up of two membrane bone elements in addition to the cartilaginous arch. The basiventralia also degenerate like the basidorsals in Urodela and here also there are spinous processes on the mid-ventral surface of the anterior connective tissue arches. Thus however diverse the vertebral arches may seem to be, all of them can be derived from the Elasmobranch type with some additional structures.

The transverse processes or diapophyses are present in the vertebrate series from Amphibia to Mammalia. The position of the diapophysis varies in the different classes and in some cases varies even in a particular genus.

In Anura the transverse process is given off at a higher level from the base on the outer side of the basidorsal. The position of the transverse process is somewhat on a lower level in Aves and Mammalia. *Triton vulgaris* which is a higher Urodela, has diapophysis or transverse process in the form of a big piece of cartilage situated at the lateral side of the basidorsal at the middle height, but the continuity between the cartilaginous cells of the transverse process and of the basidorsal, is interrupted as if by a partition between the basidorsal and the diapophysis as constituted by a perichondrial layer. In a lower Urodela, such as *Necturus maculatus*, the diapophysis is a cartilaginous rod situated at a lower level than that of *Triton vulgaris;* but this rod is bent downwards to meet the parapophysis of the basiventralia. A point to be noted here is that the posterior membrane bone arch in this form of vertebra, possesses in addition to the above, a membrane bone diapophysis. In Reptilia, the diapophysis is situated at the base of the cartilaginous basidorsal as well as at the base of the anterior or the posterior membrane bone arches as the case may be. This diapophysis has a peculiar cellular structure and was mistaken by all the previous workers for the base of the basidorsal proper.

The rib, in all cases, starts its development within the lateral myotomes, away from the vertebra, and subsequently is articulated with the diapophysis. Those ribs that have two facets, one of the facet, viz., the tuberculum articulates with the diapophysis, and the other facet capitulum articulates either with the parapophysis or with the membraneous basidorsal element as in the case of Aves and Mammalia. In the adult condition when we see a dried skeleton, this membraneous basiventral loses its identity and we find that the capitulum articulates with the body of the vertebra.

In some Anura, such as *Xenopus* and *Bombinator*, and in some Reptilia, such as *Gecko verticillatus* and *Tropidonotus stolatus* or *Naja naja*, some of the ribs are articulated with the diapophyses in the larval stage, but in the adult stage these are fused with diapophyses, thus producing a long massive

structure seemingly like diapophysis, the identity of the ribs being lost by fusion.

Successive vertebræ were yoked together in the embryonic stage by longitudinal processes that were cut into two halves by a strand of migratory connective tissues so as to produce the articular facets. The migratory connective tissue cells also divide the originally continuous perichordal tubes into vertebral segments, and the direction followed by these cells determines whether the centrum is to be of procoelous, opisthocoelous, or ampicoelous type. The course followed by the migratory cells was influenced by the movement of the embryos. The synovial cavity originates by the splitting and separation of the split halves of the strand of migratory cells while passing across the intervertebral region of the perichordal tube and its associated arches.

The developmental history of the vertebral column as revealed by the study of comparative embryology is full of significance, in as much as it shows a kind of uniformity in the processes of growth and differentiation, and gives a glimpse into the mode of origin, formation, and modification, of a morphological character which has a great bearing on the evolutionary history of the vertebrates. The results of embryological studies are of great value to the evolutionist. They probe deeper into the mysteries of life, by largely opening up the field of investigation into the realm of experimental studies on the embryonic life of animals.

The boundaries of knowledge, we know, are ever widening, and the edifice that the scientists have to build is colossal. But even the smallest contribution that one can make towards the realization of the objective, can give a supreme satisfaction that nothing else can give. And we must proceed with sincere humility in our endeavours to solve the wonderful mysteries of Nature that yet remain unsolved.

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Section of Zoology.

Abstracts.

1. Observations on *Stomatophora* from the seminal vesicle of the earthworm, *Pheretima posthuma.*

H. N. Ray *and* P. Chatterjee, Calcutta.

In this paper the authors have put down the results of their detailed observations on the suckers of the haplocyte gregarine *Stomatophora*, found in the seminal vesicle of the earthworm, *Pheretima posthuma*, in Calcutta. They have compared their accounts with those of Hesse (*Arch. Zool.*, 1910) and Bhatia (*Q.J.M.S.*, 1924) and have discussed this structure in detail.

2. Observations on a gregarine from the alimentary canal of a beetle, *Aulacophora foviecollis.*

H. N. Ray *and* P. Chatterjee, Calcutta.

Bhatia and Setna in 1924 (*Parasit.*, Vol. 16) described a gregarine from this beetle in the Punjab and called it *Caulocephalus crenata* g., et. sp., nov. The generic name, according to the above authors, is based on the cauliflower-like structure of the epimerite. The present authors have very carefully examined this gregarine from this beetle in Calcutta and have given a full account of their observations on both fresh and stained material. The cauliflower-like appearance of the epimerite in their opinion is due to the action of the fixative or any other disturbing factor introduced during the process of examination. Discussion on the dual nature of the karyosome and their staining properties, as revealed by using several stains, has also been given in detail.

3. *Eimeria* from *Natrix piscator* (Schneid).

H. Ray *and* M. Das-Gupta, Calcutta.

Oocysts of this *Eimeria* were found in the rectum of *N. piscator* in Calcutta. Oocysts measure 29μ–31μ in length and $22{\cdot}5\mu$–$24{\cdot}5\mu$ in breadth and in this respect differ from *E. tropidonoti* Guyénot from *T. natrix*. Oocystic residuum is present. Sporocysts are spindle-shaped and measure $14\mu \times 4\mu$ to 6μ. The authors propose to call it *Eimeria piscatori* n.sp.

Along with this *Eimeria* they have found oocysts of another *Eimeria* which is cylindrical in shape and measures $36\mu \times 18\mu$. In this form too there is an oocystic residuum. Sporocysts measure 14μ–$16\mu \times 6\mu$–8μ. They propose to call it *Eimera cylindrica* n.sp.

4. On an *Eimeria* from *Naja naja* Linn.

H. N. Ray *and* M. Das-Gupta, Calcutta.

This *Eimeria* was found in the fæces of a male cobra *Naja naja*. Oocysts when removed from the rectum showed an irregular mass of cytoplasm, but after being kept in 1% chromic acid for three days, the mass became round in outline. Sporocystic membrane is very thin, and in some oocysts sporozoites were seen to lie loosely without sporocysts. In this

it resembles *Paracoccidium prevoti* Lav. and Mesn. (1902). The oocyst is oval in shape and measures 18·8μ to 27·04μ in length and 18·8μ to 20·8μ in breadth. There is no oocystic residuum. The sporocyst is spindle-shaped and measures 14·6$\mu \times$ 6μ. The macrogamete has a micropyle which shows a button-like plug in fertilized ones. Schizogony gives rise to 6 to 8 spindle-shaped merozoites. The authors propose to call it *Eimeria najae* n.sp.

5. Observations on *Hyalosporina rayi* n.sp. from *Polydesmus* sp.

M. CHAKRAVARTY *and* A. N. MITRA, Calcutta.

Sporonts solitary with early intracellular growth; gametocysts spherical, measuring 96μ–120μ in diameter. Spores elongately oval with an outer hyaline investment and measuring 6·2$\mu \times$ 4·12μ. On one side of the spore there is a cap-like structure which stains deep brown with Lugol's solution.

6. On the morphology and systematic relationships of a new *Boloceroidid actinian* from brackish water, with a note on asexual reproduction.

N. KESAVA PANIKKAR, Madras.

One of the Boloceroidarians inhabiting the back-waters of Adyar and Ennore has been studied in detail. As it differs from the other Boloceroidaria in certain important features, it is described as a new genus and species, *Boloceractis gopalai*. Tentacular sphincters and ectodermal longitudinal musculature on the column are present. Spirocysts are absent from the column and there is no columnar sphincter. There is no sharp differentiation of mesenteries into macrocnemes and microcnemes; and the fertile mesenteries of the anemone include both the perfect and imperfect ones, though the gonads are usually borne by the latter. Directive mesenteries and siphonoglyphes are present. Asexual reproduction is common in the anemone, mainly by the regenerative activity of the deciduous tentacles, the process being somewhat similar to that observed for *Boloceroides*, the nearest related genus. The systematic relationships of the anemone and the process of asexual reproduction are discussed.

7. A study of the actinian *Phytocœtes gangeticus*, with notes on post-larval stages and the occurrence of pædogenesis in the anemone.

N. KESAVA PANIKKAR, Madras.

The habits, anatomy and post-larval development of the brackish water actinian *Phytocœtes gangeticus* Annandale have been studied. The mesenterial and tentacular arrangements of the Actinian follow the typical plan. Most of the specimens had six macrocnemes and two other cycles of microcnemes, with four cycles of tentacles, while a few had an incomplete fourth cycle of mesenteries and a fifth cycle of tentacles. Of the six pairs of macrocnemes, the eight Edwardsia mesenteries are much better developed than the mesenteries of the fifth and sixth couples, and even among the former set, those belonging to the first and second couples are the most prominent. These features recall the faint Edwardsian bilateral symmetry in the arrangement of the mesenteries seen in some of the primitive Halcampoid anemones. Acontia are present in a few of the older couples of mesenteries and this settles the position of the

genus *Phytocœtes* in the Halcampactiidæ. The acontial cnidæ include both penicilli and spirulæ, but the majority of capsules belong to the former type, spirulæ being scarce. The distribution of acontia and gonads studied in several specimens shows that their degree of development in the different mesenteries corresponds to the order of succession of macrocnemes. The mesenterial filament is fairly well organized, but the trifid portion of the filament is very small and the ciliated tracts are occasionally discontinuous as in *Scytophorus antarcticus*, *Halcampoides purpurea*, *Isooedwardsia mediterranea*, and *Limnactinia lævis*. The early phase of development appears to be quick as the tentacles appear very early in development. The adult organs like the acontia, filaments, etc., begin to appear even in the Edwardsia stage. These are fairly organized by the post-Edwardsia stage, which appears to be prolonged as the development of the last two couples of mesenteries is slow and the adult features appear before all the macrocnemes are well developed. Some specimens belonging to the Edwardsia and post-Edwardsia stages had well developed egg cells in some of the mesenteries. This is strongly suggestive of the occurrence of pædogenesis in the anemone. Accounts of the habits, habitats, and distribution of the anemone are given. Structural and developmental features and the question of pædogenesis are discussed.

8. On a new trematode from the intestinal cæca of a wigeon, *Mareca penelope*.

M. B. Lal, Lucknow.

A large number of these parasites were obtained from the intestinal cæca of the host which, when brought to the laboratory, showed symptoms of great lassitude and died the same night. The post-mortem revealed a heavy infection with Trematodes and Cestodes.

The new form described in the present paper differs from the allied ones in the position of the genital pore, the number and arrangement of the ventral glands, the position of uterine coils and most strikingly in the anterior extent of the vitellaria.

The details of its morphology and systematic position are discussed in the paper.

9. On a nematode from *Calotes versicolor*.

G. K. Chakravorty, Calcutta.

A parasitic nematode of the genus *Strongyluris* has been found in the rectum of *Calotes versicolor*. The different systems of the worm have been described in this paper.

10. On a *Microfilaria* from the blood of *Columba intermedia*.

H. Ray *and* M. Das-Gupta, Calcutta.

The morphology of a new species of *Microfilaria*, *Mf. columbæ* n. sp., has been described in detail. In the absence of any data about the adult worm it has been found difficult to state definitely whether this microfilaria is the larval form of *Eulimdana clava* (Wedl). Study of the sections of different tissues of the host has shown that every tissue is infiltrated by this organism, and in certain places it is found to rupture the capillary and invade the tissue proper. The mean percentage measurement in microns of 20 specimens is given below :—

C.S.—2·88; N—18·65; N. Exp.—6·29; Ex. P.—24·97; Ex. P.-Ex. Z.—5·52; Ex. Z.—31·82; Ex. Z.-G_1. Z.—36·87; G_1. Z.—69·27; Ex. P.-A.P.—54·87; G_1. Z.-A.P.—12·03; A.P.—81·31; L.S.Z.—93·18; L.S.Z.-S.—6·65.

Mean total length of 20 specimens is 363·9μ.

11. Report on the filariasis enquiry at the Calcutta School of Tropical Medicine.

R. KNOWLES, B. C. BASU, *and* S. SUNDAR RAO,
Calcutta.

This work aims at determining the limits of atmospheric temperature and relative humidity at which transmission of filariasis may occur. For this purpose batches of clean laboratory bred *Culex fatigans* were fed on suitable cases of filariasis (with filarial embryos in the peripheral blood) between 10 and 11 P.M. and put up in Barraud cages and exposed at 22 (so far) different combinations of temperature and humidity in the air-conditioning cabinet at which any temperature between 50°F. and 100°F. and relative humidity between 50% and 100% can be adjusted. In each case a microfilaria count of the patient's blood was made before the feed (the counts varying from 7 to 252 microfilaria in 0·2 c.c. of blood) in order to ascertain the minimum number of microfilaria in donor's blood which will be infective to mosquitoes. The survivors were dissected after varying intervals of time to test their infectivity.

The work is in progress and the report is a preliminary one, but already the following information has been gleaned :—

(i) Both temperature and relative humidity play a very important part in the transmission of filariasis in man by *Culex fatigans*.

(ii) A minimum of 12 microfilaria per 0·2 c.cm. peripheral blood has been found infective to mosquito.

(iii) At a temperature of 100°F. with relative humidity between 50% and 100% transmission of filariasis does not seem possible as the mosquitoes do not survive till the infective period.

(iv) At 90°F. and relative humidity between 50% and 70% no infection was seen in mosquitoes ; but at the same temperature and high humidities between 80% and 100% a fairly heavy percentage of survived mosquitoes were infected.

(v) At 80°F. and 90% and 100% relative humidity a very heavy percentage of mosquitoes become infected, in fact 100% infection was seen at 80°F. and 90% humidity. Thus this seems to be the optimum condition.

(vi) At 70°F. and humidities between 70% to 100% a fairly heavy percentage of infection has been seen, but at the same temperature and lower humidities no infection has been seen.

(vii) At 60°F. and between 70% to 100% relative humidities a very poor percentage of mosquitoes get infection, and at the same temperature and lower humidities none are infected. At lower temperatures the longevity of mosquitoes increases but the minimum time taken for the development of the filarial embryos is very long; thus transmission in nature is doubtful at lower temperatures.

(viii) The minimum time taken for the complete development of the filarial embryo to their appearance in the proboscis of the mosquitoes was 9, 10, 20 and 47 days at 90°F., 80°F., 70°F., and 60°F. temperatures respectively.

(ix) All the evidence goes to show that the monsoon period of Calcutta is that at which maximal infection of fed mosquitoes occurs and that the cold weather is very unfavourable for the development of microfilaria in mosquitoes.

12. Observations on the *Echinococcus* cysts from sheep and goats in Lucknow.

G. S. THAPAR, Lucknow.

Much attention has been paid to this problem, particularly in view of the danger of its transmission to man. A survey of the several cysts

recovered from various parts of the animals killed at the slaughter-houses in Lucknow has been made. Its occurrence in the lumbar region of a lamb is recorded for the first time.

Certain experiments were performed by opening the cysts and keeping them in various nutritive solutions, and observations were made on the developmental stages outside the body of the hosts, particularly with regard to evaginations of the scoleces.

The value of the different nutritive solutions is also discussed in the paper.

13. Accessory ovaries in *Megascolex mauritii.*

T. K. Gopalachari, Cocanada.

In *Megascolex mauritii* accessory ovaries occur as almost a regular feature in the segment XIV. They are small and contain a few ova clustered into a compact mass. The ova are as big as the ova of the normal ovary in the segment XIII. There is no outlet for the accessory ovaries. This is the first record of the occurrence of additional ovaries in *Megascolex.*

14. The excretory system of the leech *Hirudinaria.*

M. L. Bhatia, Lucknow.

The excretory system of this leech consists of seventeen pairs of nephridia disposed metamerically in somites VIII to XXIV. The first four pairs lie anterior to the genital organs, the fifth and sixth pairs in the segments occupied by the epididymes and female genital apparatus respectively; while the remaining eleven pairs occur in segments XIV to XXIV and co-exist with the testis-sacs in these segments. The typical nephridium of the testicular region consists of (*a*) the *testis lobe*, (*b*) the *main lobe*, (*c*) the *recurrent lobe*, (*d*) the *apical lobe*, and (*e*) the *vesicle.*

The testis lobe in the first six pairs of nephridia is very much reduced or even absent.

In *H. medicinalis*, the testis lobe, according to Bourne, comes in close relation with the testis-sac, and the end of testis lobe is slightly enlarged to form a ciliated funnel. In *Hirudinaria* it is seen that the testis lobe of the nephridium presents any of the three following conditions: (1) it may either terminate far away from the testis-sac and thus have no connection with it at all, (2) it may become applied to the surface of the testis-sac, but still have no connection with the funnel, (3) the testis-lobe may enter the peri-nephrostomial sinus of the testis-sac and its free end may be connected with the funnel.

15. Adaptive peculiarities of some estuarine species of the genus *Thalassema* Lam.

B. Prashad, Calcutta.

In 1919 the author recorded *Thalassema branchiorhynchus* Annandale and Kemp from the mud flats at Chandipur, Orissa, on the coast of the Bay of Bengal, and described a new species, *Thalassema microrhynchus*, from the same area. In discussing the adaptive peculiarities of the species in reference to the development of gill-like processes on the free ventral margins of the proboscis of *T. branchiorhynchus* Annandale and Kemp, the author pointed out that adaptive characters of exactly opposite type were developed in the two species living under identical conditions, apparently in response to the physical and biological conditions of the area concerned. Recently, when dealing with a collection of unnamed material of the genus *Thalassema* in the Indian Museum from different

areas, the author described a new species *Thalassema marshalli* from the estuarine waters of the Irrawaddy, near Rangoon, Burma. In this species the gill-like processes, which are developed on the ventral free margins of the proboscis, are of an entirely different character from those developed in another species, *Thalassema arkati* Prashad, from the Sandheads, off the mouth of the river Hooghli. The morphological significance of these adaptive structures is discussed and attention is directed to the fact that different species of the genus have evolved, along different lines, structures adapting them to the peculiar biological surroundings in which they live.

16. Secretion of fatty and albuminous yolk by Golgi bodies in *Stomopneustes variolaris* (Lamarck).

M. K. Subramaniam *and* R. Gopala Aiyar, Madras.

One of the authors has shown in a previous paper that fatty and albuminous yolk arise in relation with the Golgi bodies in *Clibanarius*. It was then hoped that a similar demonstration in some other animal of an entirely different phylum will once for all set at rest the controversy regarding the function of Golgi bodies in oogenesis. They are now in a position to present such an evidence, the animal being *Stomopneustes variolaris*, a common urchin from the Madras Harbour.

The Golgi bodies occur in the youngest oocytes as discrete granules. During growth a differentiation sets in leading to the formation of a chromophilic rim and a chromophobic interior. Some of these remain unmodified throughout oogenesis. Some others grow into vacuoles with rims, fatty yolk being deposited in the interior of the vacuole. The rim does not undergo any transformation.

Prior to the secretion of albuminous yolk the mitochondria clump together. The Golgi vesicles by rupture give rise to scale or batonette-like bodies. These attach themselves to the mitochondrial clumps and secrete albuminous yolk.

The origin of fatty and albuminous yolk in relation with the Golgi bodies only confirms the belief that the nature of the action of the apparatus is only by means of enzymes and that fat, fatty yolk, and yolk are only products resulting from the action of these enzymes on materials derived from the cytoplasm, mitochondria, nucleolus, nutritive bodies, etc.

17. Effect of the frequency of copulation on the fertility of eggs of *Bruchus quadrimaculatus* Fabr.

Durgadas Mukerji *and* A. H. Bhuya, Calcutta.

Previous workers paid attention to the influence of temperature and moisture on the number of eggs laid by females. In this paper observations on the mating habit, and the number of eggs laid by females after single and multiple copulations are recorded. Parthenogenesis does not occur and polygamy is common. Repeated matings tend to decrease the fertility.

18. Sensory filaments of the 'medial lobe' of the male of *Bruchus quadrimaculatus* Fabr.

Durgadas Mukerji *and* A. H. Bhuya, Calcutta.

At the apical end of the 'medial lobe' which was designated by the authors in their previous communication to the Zoology Section of the Science Congress, as the phallic capsule, a bunch of sensory filaments

occur. These filaments are peculiar to *B. quadrimaculatus* only and have not been found by them in any other species of the Bruchidæ. The filaments are long and tapering, and are swollen into a bulb at about one-third its distance from the point of insertion of each filament. The structure and function of their filaments are described in this paper. The filaments are withdrawn into and guard the external aperture of the 'medial lobe' when the terminal portion of the intromittent organ is invaginated within the medial lobe.

19. Occurrence of ovaries in the worker of the ant *Œcophyla smaragdina*.

DURGADAS MUKERJI *and* A. H. BHUYA, Calcutta.

Since workers have been observed to lay eggs which develop into workers, the condition of ovaries in the different phases of the species is investigated in this paper. The state of reproductive activity of the workers has an important bearing on the problem of polymorphism of the ant.

20. Anopheles breeding in relation to aquatic vegetation.

P. SEN, Calcutta.

In this article an attempt has been made to correlate some of the very commonly met with aquatic vegetation in the water-collections of Bengal with particular species of Anophelines. The results obtained for some species are very encouraging and are of great biological importance.

21. Recent records of South Indian Coccidæ.

T. V. RAMAKRISHNA AYYAR, Coimbatore.

This paper includes a preliminary account of the recent studies made by the author on the taxonomy, bionomics, and host relations of S. Indian Coccidæ, being a continuation of the work started by him over twenty years ago. About half a dozen papers have been published by him, the first paper being read before the Indian Science Congress at Lahore in 1918. The most important of the writer's publications on this group of insects is the profusely illustrated Bulletin on South Indian Coccidæ published by the Imperial Department of Agriculture in India in 1929. As a result of further work in this direction since then fresh data have accumulated, and in this paper, which forms a supplement to the previous papers, a brief summary is given of the notes taken on over thirty species of Coccidæ. Of these, six happen to be species new to science and seven forms fresh records for the South Indian region. The new species noted are *Lepidosaphes cornutus*, *Cerococcus ramakrishnæ*, *Ripersia puntatissima*, *Ripersia oryzæ*, *Pseudantonina rigida*, and *Pseudantonina imperatæ*; of the new records for the region the most interesting are *Ceronema kœbeli* and *Kermicus wroughtoni* N. Some recent alterations in the synonymy of some forms are also added.

22. On a new species of *Stiliger* with a note on its breeding and spawning habits.

K. VIRABHADRA RAO, Madras.

A species of Ascoglossa of the genus, *Stiliger* (Ehrenberg), new to science, observed among the floating algæ in the brackish water pools near the mouth of the river Cooum and in the backwaters of Adyar is named *Stiliger gopalii*. An account of its external features and internal anatomy is given in this paper.

S. gopalii differs from any species that have hitherto been described, but combines in itself several characteristics of different species of the genus. In the position of the anus, the general shape of the body, the presence of a single pair of long and slender tantacles, the absence of jaws, and in the presence of a radula of the Ascoglossa type and of penial armature, the present form agrees with all others of the genus. It differs from *S. mariæ* in the nature of the radula, cerata, and penial armature. The radula of the present form closely resembles that of *S. varians* but the species is distinct from it in its habitat, colour, and hepatic ramifications in the cerata. The absence of a notch in the oral veil and of the antero-lateral lobes of the foot, and the nature of the teeth of the radula in *S. irregularis* are characteristic, and distinguish it from the present species. *S. tentaculata* differs from all others of the genus in having well developed oral tentacles. The ground colour of the body and the spawn of *S. viridis* distinguish it from the present species. The nearest ally of this species seems to be *S. pica*, from which it differs in the position of the eyes, the presence of a distinct filamentous tail and of a few clear white spots on the foot, and in the nature of the radula and of the hepatic ramifications in the cerata.

It was possible to keep the animals alive in the laboratory for over a month in brackish water brought from their natural environment. The animals very frequently came together to copulate. The process of copulation is described. The spawn is deposited a few hours after copulation. As the eggs extrude, they are arranged spirally and agglutinated in a jelly-like substance to form cylindrical strings, each containing 700 to 1,000 minute eggs.

The general development of the eggs until the emergence of the veligers has also been worked out.

23. Absorption of food in *Melania* (*Radina*) *crenulata* (Desh.) var. *tirouri* Fer.

R. V. SESHAIYA, Annamalainagar.

Feeding experiments carried out to determine the mode of absorption of food are described.

The cells of the digestive gland are able to ingest *insoluble* particles.

Intra-cellar digestion occurs in the cells.

Ingested particles are collected in vacuoles, and later condensed into larger masses surrounded by a secretion ; undigested matter is thrown out into the lumen of the tubules of the digestive gland.

The 'concretions' seen usually in the cells of the digestive gland consist of ingested material undergoing digestion or about to be eliminated. Their nature depends entirely on the food taken by the animal ; they diminish in number during starvation.

The so-called 'ferment cells' appear to be only 'gland' cells in a later phase of digestion. As they get worn out they are replaced by fresh cells which appear on their sides.

24. The structure of the pyloric cæca in the fam. *Mastacembelidæ.*

M. RAHIMULLAH, Hyderabad.

In previous years the author attempted to give an account of the pyloric cæca as found in the families Ophicephalidæ and Notopteridæ. A paper on the group Ophicephalidæ has already been published in *Anat. Anz.*, vol. 80, 1935.

This year the author proposes to speak something about the cæca as they exist in the family Mastacembelidæ, especially dealing with the condition in *Rhynchobdella aculeata* Bloch. In this fish the intestine

is quite simple and short, forming a single loop and the two cæca are comparatively smaller, and arise at a short distance behind the sharp bend of the pylorus. They are almost equal in size, although in some specimens the left cæcum is slightly thicker than the right one.

In a fish measuring 14·0 cms. in length the ratios of the lengths of the cæca (each taken as a unit) to those of the intestine and the whole of the alimentary tract are nearly 1 : 14 : 6 and 1 : 25 : 1 respectively. Cæca are also found in *Mastacembelus armatus* (Lacép) and *M. pancalus* (Ham. Buch.).

Histological details, blood- and nerve-supplies have also been studied and described.

25. Further observations on the structure, bionomics, and physiology of an air-breathing loach, *Lepidocephalus guntea* (Ham. Buch.), found within H.E.H. the Nizam's Dominions.

B. K. Das, Hyderabad.

In 1934 at the Bombay session of the Science Congress, the author reported about the mode of intestinal respiration in this loach. This year he proposes to discuss in greater detail further observations, especially based on the following points :—

(i) The histology of the intestine of the fish as correlated with the aerial mode of respiration ;

(ii) Further experiments on the physiology of respiration.

26. Types of Indian fish found impacted in the food and air passages of men.

S. L. Hora, Calcutta.

In a series of three articles Gudger (*Arch. Path. Lab. Med.*, II, pp. 355–375, 1926; *ibid.*, IV, pp. 346–355, 1927; *Amer. Journ. Surgery*, XXII, pp. 573–575, 1933) has brought together from all over the world 38 recorded cases of live fishes impacted in the food and air passages of men. 12 of these refer to India. As the result of a recent enquiry through Major-General D. P. Goil, Surgeon-General with the Government of Bengal, 18 more cases from India have come to light.

Out of 30 Indian cases, 17 were due to *Anabas* (Koi), 3 to *Colisa* (Kholisha), and 1 each to *Mastacembelus*, *Therapon*, and *Cynoglossus*. The types of fish concerned in the remaining 7 accidents are not known.

Both *Anabas* and *Colisa* are Labyrinthine fishes which are provided with organs of aerial respiration and, in consequence, remain lively even out of water for a considerable time. They are provided with a series of backwardly directed spines on the gill-covers and in front of the dorsal and anal fins. *Mastacembelus* is a compressed eel-like fish with a series of sharp, strong, and backwardly directed spines along its back, in the anal fins and on the gill-covers. *Therapon* is a Percoid fish with a number of backwardly directed spines in the vertical fins and on the gill-covers. In *Cynoglossus* the vertical fins extend right up to the head and the rays are directed backwards. Such fishes, if impacted in the throat with the head directed inwards, will be very difficult to pull out.

In most cases the fish were found impacted in the throat or the food-passage. The form of *Anabas*, *Colisa*, *Therapon*, and *Cynoglossus* is such that they cannot gain entrance into the narrow air-passages. *Mastacembelus*, with its pointed head and eel-like body, can, however, enter narrow passages, and six cases are recorded in which this type of fish was found impacted in the air-passages.

The paper was illustrated with lantern slides, and the types of fish discussed above were exhibited.

27. The anatomy and histology of the alimentary system of *Otolithus ruber* (Bl. Schn.).

M. Dharmarajan, Madras.

The general morphology and histology of the various parts of the alimentary tract are described. The fish is carnivorous. The stomach is of the cæcal type and the pylorus arises as a tube from its anterior part. There are five pyloric cæca. In the mouth, the presence of peculiar papillæ occurring anteriorly, external to the teeth, has been described and their histology reveals the fact that their function is to increase the mucus-secreting and gustatory surface.

The taste buds in the mouth show a restricted distribution, occurring only on the tongue and the papillæ, the buccal epithelium being devoid of them. In addition to the normal cells, 'ovoid cells' whose function is doubtful, are described in the papillæ and buccal epithelium. Both the pylorus and a funnel-like part of the stomach around the pyloric exit are devoid of gastric glands.

The pyloric valve is made up of a ring of flaps, but is peculiar in that there appear to be no muscular extensions into them. A novel but simple method of the working of this form of valve is suggested. The intestino-rectal valve is a vellum-like projection into the lumen of the tract. From its structure it appears to work like an iris-diaphragm.

Definite empty spaces, lined each by a cellular wall, occur between the submucosa and the circular muscles both of the intestine and rectum. An anal sphincter is absent.

Examination of the stomach contents of a large number of fish has revealed the presence solely of the Crustacean *Acetes erythræus*. 'Selective feeding' probably exists in this case.

28. Correlation between modifications of the air-bladder in the Gobioid fishes of the Gangetic delta and their habitats.

Dev D. Mukerji, Calcutta.

In February, 1935, Dr. S. L. Hora (*Cur. Sci.*, III, pp. 336–338) discussed the modifications of the swim-bladder in certain air-breathing fishes of India and referred to the correlation between the form of the bladder and the mode of life of the estuarine Gobioid fishes. The detailed study of this problem was entrusted to the author by Dr. Hora.

The air-bladders of *Glossogobius giuris*, *Ctenogobius nunus*, *Gobiopterus chuno*, *Stigmatogobius sadanundio*, *Taenioides rubicundus*, *Apocryptes bato*, *Pseudapocryptes lanceolatus*, *Boleophthalmus boddaerti*, and *Periophthalmodon schlosseri* were investigated. These species can be classed into three principal ecological groups, *e.g.* (i) aquatic forms, such as *G. giuris*, *C. nunus*, *G. chuno* and *S. sadanundio*, which move about freely and can use air-bladder for hydrostatic purposes, are provided with fairly extensive bladder in the abdominal cavity, (ii) semi-aquatic forms, such as *T. rubicundus*, *A. bato* and *P. lanceolatus*, which live in burrows and are exposed to dry conditions at times, have their bladders greatly reduced and modified in different ways in accordance with their habitats, and (iii) almost terrestrial forms, such as *B. boddaerti* and *P. schlosseri*, which spend most of their time out of water and in consequence the air-bladder is totally absent or vestigial in adult stage. Besides this apparent correlation between habits and habitats, a detailed study of the structure of the air-bladder on the one hand and the ecological factors in the habitats of the different species on the other shows a remarkable adjustment between the estuarine species of the Gobioid fishes and their environment.

29. The arterial system of the common Indian bull-frog *Rana tigerina* Daud.

J. L. BHADURI *and* G. N. MITRA, Calcutta.

Parker and Bhatia (*An Elementary Text-Book of Zoology for Indian Students*, 1932) have given an unsatisfactory diagram of the vascular system of *R. tigerina*, and their description of the arterial system refers unfortunately to some European species. Crawshay (*P.Z.S.*, 1906) has, however, given an account of the arterial system of *R. tigerina* in way of comparison with other frogs of the genus *Rana*, but his observations are based on an examination of a single specimen. The arterial system of *R. tigerina*, as studied by the present authors, differs in details from other accounts of frogs of the genus *Rana*. But there exists still a good deal of confusion with regard to the nomenclature of the various parts of the heart and different arteries. It is with a view to this that the authors have attempted to provide in this note a suitable account of the arterial system of *R. tigerina*.

30. A short note on the occurrence of papillæ-like structures in the buccal cavity of the tadpoles of *Megophrys parva*.

J. L. BHADURI, Calcutta.

The author desires to record the occurrence of short blunt papillæ-like structures in the buccal cavity of the tadpoles of *M. parva*. They are arranged in a circular row behind the horny jaws. A short histological note is also given.

31. Hermaphroditism in *Rana tigrina*.

T. K. GOPALACHARI, Cocanada.

The author came across two specimens of *Rana tigrina* showing hermaphroditism. Externally these frogs had all the characters of the male, but internally each had a pair of oviducts with distinct thin-walled uteri and openings into the cloaca. No ovary was present but the testes were unequal and the left testis in one of the frogs was large and irregular with globular prominences.

32. Observations on the occurrence of *Pitta c. cucullata* Hartl. in West Bengal.

S. C. LAW, Calcutta.

A pair of these species observed on June 23, 1935, in Satgachia, 20 miles east of Burdwan town, of which one was captured alive in perfect breeding condition. The find is singular and striking in view of absence of recorded data from West, and even Central Bengal. Sexual display and courtship behaviour (as observed by the author) described. Habitat discussed in reference to ecology of the area (Satgachia) in which the species is found and collected: the physical features analogous in many respects to the deltaic alluvium of Central Bengal, yet differing from it and evincing a tendency to transfusion with characteristics of the neighbouring rocky, non-alluvial zone. Distributional data available in other parts of the plains districts of Bengal, chiefly North and Eastern Bengal.

33. The vacuome hypothesis.

D. R. BHATTACHARYA *and* M. D. SRIVASTAVA, Allahabad.

Supra-vital experiments with a number of vital dyes were conducted on the freshly teased out ovarian tissue of *Columba intermedia*, *Gallus bankiva*, *Rana tigrina* and *Saccobranchus fossilis*. The vacuome and Golgi bodies were found as discrete elements confined to the juxtanuclear cytoplasmic area, called the Yolk Nucleus of Balbiani, in the early oocytes, from where they spread out later on. The two elements can be simultaneously demonstrated and are apparently independent. The arrangement of the vacuome in the egg varies in different animals.

34. Preliminary observations on changes in salinity of the surface waters at the Sandheads.

B. CHOPRA, Calcutta.

Through the courtesy of the members of the Bengal Pilot Service the author has been carrying on observations on the salinity of the surface waters at the Sandheads off the mouth of the river Hooghli since May, 1933. During a period of about two years a series of water samples was obtained more or less regularly once a month. Each series consisted of twelve samples taken at two-hourly intervals, so that a complete period of 24 hours was covered every month. The exact position of the ship, the condition of the tide at the time the sample was taken, and the temperature of the water were recorded.

The titration of these samples has given a fairly accurate idea of the changes that take place in the salinity of the surface waters from month to month and also with tidal changes.

The data are still being worked out in detail, but some interesting results have already been obtained. These are briefly discussed in the present note.

35. Rôle of salinity in mosquito ecology.

P. SEN, Calcutta.

Mosquito-breeding in various natural waters in lower Bengal shows that some species of Anophelines are indifferent to salinity and others are highly sensitive. There appears, however, no sharp limiting factor in salinity, but waters in which this is high are not favoured by most species. The salinity of breeding water may not have any direct effect on the life of the mosquitoes, but possibly this plays an important rôle by inhibiting growth of food organisms, specially macroscopic algæ.

36. On the food factor of the so-called mosquito-destroying fishes of Bengal.

P. SEN, Calcutta.

Numerous dissections of the surface-feeding fish of various species that are commonly met with in tanks, ditches, and rice-fields of Bengal have been carried out immediately after they were collected from their natural habitats. The analyses of food contents of guts in these fish showed that mosquito larvæ formed only a fragmentary part of the diet. Various other insects that were recorded from inside the fish-stomachs have been enumerated. Majority of these fish are omnivorous, a considerable portion of the stomach contents being formed of vegetable matters.

37. The brackish water fauna of Madras.

R. GOPALA AIYAR *and* N. KESAVA PANIKKAR, Madras.

The Adyar backwater and the estuary of the tiny Adyar river, which are in close association, form a typical brackish water realm, harbouring a fairly rich and characteristic fauna. The connection between the brackish water and the sea is retained only during the North-East Monsoon period and the two succeeding months; in summer, this connection is cut off by the 'bar' and the level of the water falls considerably leaving the mud-flats on the marginal zone of the backwater exposed. There is also a great fall in salinity. Owing to the influence of tides, the flow of fresh water down the river, and the presence of shallow mud-flats and pools surrounding the backwater, the salinity and temperature are subject to great fluctuation. Detailed information on salinity, temperature, *pH*, etc. have been obtained. The fauna has a predominant marine element and includes: (1) marine and euryhaline species found both in the sea and the backwater; (2) brackish water species of marine origin, but now unrepresented in the sea; and (3) fresh water species which are acclimatized for brackish water life. The first two groups comprise the majority of forms and include representatives of all the marine major invertebrate phyla except the Brachiopoda and Echinodermata. The Cœlenterata, Polychæta, and Crustacea were studied in detail. Of the nine Cœlenterates, six were Actiniaria belonging to the families Halcampactiidæ and Boloceroidaria. The Actinian fauna includes the characteristics Halcampactids *Pelocœtes exul* known from Chilka Lake and Gangetic Delta, and *Phytocœtes gangeticus* hitherto known only from the Gangetic Delta. The other two Halcampactids are new forms. One of the Boloceroidaria is characterized by enormous powers of asexual reproduction. The Polychæt fauna comprises many forms described from the Gangetic Delta and the Chilka Lake. While most of the Chilka Lake species are represented, characteristic Gangetic forms like *Matla*, *Spio*, and *Barantolla* have not been obtained, though *Lycastis indica* and *Nereis glandicincta*, which are known from the Gangetic Delta and unrecorded from the Chilka Lake, are very common. Some of the brackish water Polychæts like *Lycastis indica* and *Lumbriconereis polydesma* are gradually getting adapted to fresh water conditions, while the former has also taken to a partly amphibious mode of life. The Crustacea include numerous Grapsoid and Ocypod Crabs among the Reptantia, and species of *Peneus*, *Leander*, *Alpheus*, and other Caridea among the Natantia. Two euryhaline Mysids are very common, of which *Rhopalophthalmus egregius* is mainly a migrant, while the other, *Macropsis orientalis* is a permanent item in the plankton. Among the fishes, the Gobiidæ are the best represented.

The general features of the fauna are the large number of amphibious and mud-burrowing species, the occurrence of highly resistant types in enormous numbers and the zonation of the majority of the animals near the water edge. Amongst the numerous adaptations may be mentioned: (1) the curtailment of life-history and the absence of pelagic stage of development as illustrated by the life-histories of Polychæts; (2) the enormous powers of reproduction as seen in many Gastropod Mollusca; (3) the early attainment of sexual maturity and the occurrence of asexual reproductive processes in some Actiniaria; (4) devices for aerial respiration in Crabs, Molluscs, and Fishes; (5) adaptation towards burrowing life by the greater development of organs designed for that purpose; (6) the capacity for remaining inactive during periods of drought; and (7) increased integumental protection and mucus secreting devices which serve to overcome the adverse effects of exposure, sudden changes in salinity and the foulness of the environment.

A detailed account of some of the more interesting forms inhabiting the backwater, illustrating these points is given and the life-histories of some of the Polychæts and Actinians are described for the first time.

38. The maximum number of meals of a wild sand-fly (*Phlebotomus argentipes*, ♀) under laboratory conditions.

S. Mukerji, Calcutta.

In view of the rôle played by the members of the genus *Phlebotomus* in the transmission of protozoal parasites of pathogenic importance, an exact knowledge of its bionomics and, more specially, of its feeding habits are of considerable importance. It is with this end in view that the author carried on the following experiments to determine the exact nature of feeding habits of wild *P. argentipes*.

About 30 females of *P. argentipes*, forming part of a day's catch, were kept on 23rd August, 1935, in a small cage for a first feed on a mouse; out of these 18 were found to have fed overnight. Only two died on 26th August and the rest numbering 16 were put in a cage for a second feed; out of these 12 were found to have fed overnight. Three died on 29th August and the remaining 9 were kept in a cage for a third feed. Four were found to have fed next morning. All the fed ones survived up to 31st August and these were kept for a fourth feed. Next morning 2 were found to have fed. On 2nd September the 2 fed flies were kept overnight for a fifth feed; both of these took a blood-meal overnight. The 2 fed ones survived up to 4th September and were put up for a sixth feed. The couple fed and survived up to 7th September when they were put up for a seventh feed; only one was found to have taken a blood-meal overnight. The fed 1 survived up to 8th September when it was found unhealthy and was killed and dissected. It will thus be seen from this laboratory experiments that about 3% of the wild flies lives up to 16th day from their time of capture to reach the maximum feed.

39. The nature of the blood-meal of Indian Culicoides.

S. Mukerji, Calcutta.

While surveying the endemic Kala-azar areas of Calcutta and its environs for blood sucking arthropods, it was thought necessary to accurately determine the nature of the blood-meal of some of them. Besides the ubiquitous mosquitoes and sand-flies a few species of *Culicoides* (Chironomidæ) were found in the cattle sheds. The following results were obtained as to the nature of the blood-meal of the *Culicoides*: Human—5·5%; Ruminant—91·6%; others—8·3%.

40. Observations on the spawning habits of the carp *Labeo gonius* (Day).

Nazir Ahmad, Lahore.

At a previous session of the Science Congress 1933 the author submitted a paper on "Preliminary study of the embryology of *Wallago attu*". He has now observed spawning of *Labeo gonius* on the banks of Budha Nala, Ludhiana, on 20th July, 1935, following rain and flood. 90 developmental stages of fish comprising 35 half-hourly, 12 one-hourly, 25 two-hourly, 8 three-hourly and 10 six-hourly, were collected. The results of the study of these stages are recorded in this paper.

It was noted that embryos hatched out ten hours after fertilisation at atmospheric temperature ranging between 78° F and 82° F.

Section of Anthropology.

President :—H. C. Chakladar, Esq., M.A.

Presidential Address.

PROBLEMS OF THE RACIAL COMPOSITION OF THE INDIAN PEOPLES.

Half a century has elapsed since Sir Herbert Risley, with a view to a racial analysis of the people of India, began about 1884 to have anthropometric measurements taken of them by certain assistants to whom he had given a training himself. Six years later, in 1890, this great pioneer of ethnic investigations in India published a summary of the measurements thus taken, of 87 tribes and castes of Northern India, including Bengal, Bihar, Chota Nagpur, the United Provinces, and the Punjab, in the *Journal of the Anthropological Institute of Great Britain*, under the title, 'The Study of Ethnology in India'. In this same paper he proceeded, on the basis of these anthropomorphic data, to classify the people living in this area into three main types which he provisionally named *Aryan*, *Dravidian*, and *Mongoloid*, and Risley assures us that this racial classification of his of the Indian peoples was accepted by the European scientists of the time.[1]

The detailed anthropomorphic data referred to above were published in India in 1891, in two volumes, and in the years following, Risley had a similar anthropometric survey carried out in Baluchistan, Rajputana, Bombay, Orissa, and Burma. In the Madras Presidency, anthropometric data were collected by Thurston from measurements taken by himself, 'in order to eliminate', as he says, 'the varying error resulting from the employment of a plurality of observers'.[2] Holland contributed some data for the Coorgs and Yeruval of Southern India and the Kanets of Kulu and Lahoul. Besides, Waddell measured about 600 individuals belonging to 33 tribes of the Brahmaputra valley, and he thus speaks of his method: 'The measurements were all taken by me with a set of instruments made by Collin of Paris. Scrupulous care was ever exercised to secure precision in these anatomical records, and also to exclude from the series every individual suspected to be in any wise impure in type. The data thus laboriously obtained are therefore necessarily more trustworthy than those published in regard to a few of those tribes on the Bengal border by Mr. Risley, whose measurements recorded in his "Castes and Tribes of Bengal" were made

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[1] *Census Report of India*, 1901, vol. I, p. 494.

[2] *Castes and Tribes of Southern India*, vol. I, p. xii.

by a Bengali Hospital Assistant, who wandered about measuring individuals under nobody's immediate supervision '.[1]

Dr. Waddell, by virtue of his knowledge of anatomy, was no doubt much better qualified than Risley's assistants to take somatometric measurements, and his measurements also possess the advantage of having been recorded by a single investigator, while Risley's data were obtained by different workers in different provinces. But he naively admits a serious defect in his method which takes from the scientific value of his measurements, viz. that he introduced the principle of selection in it, in common with Risley. The latter instructed his assistants ' in measuring the higher castes to reject persons of very black complexion and with very broad and depressed noses, as in such cases there is at least a suspicion of the intermixture of low-caste blood. Similarly among the lower castes, men of very fair complexion and high-caste type of feature should be rejected. The object is to determine the standard type of each caste, and for this purpose individuals of clearly exceptional colouring and feature should be excluded '.[2]

Another defect that mars the scientific value of these measurements is that many of the samples of all these investigators were too small to afford any reliable data for comparison with other ethnic types, and Waddell's series suffer most in this respect. Only in the case of one tribe, viz. the Koch, does the number of individuals measured exceed fifty, while in most of the others it falls below 20, and even below 10 in some cases, and of one tribe he had measured only a single individual. We must, however, appreciate the difficulties under which Waddell worked ; he was measuring mostly savage tribes in the wild glens of a mountainous district, and we must thank him for the few measurements recorded by him in this unfavourable region. Since his time very little anthropometric work has been done among these wild peoples, though our knowledge about the social organization and religious beliefs of many of them has been considerably augmented. The Anthropology department of the Calcutta University has been sending workers among these wild peoples, especially Nagas and Kukis, and a few samples including a hundred or more individuals in each have been obtained.

Thurston's series also are not most of them large enough for scientific purposes : the size of no one of his samples goes up so high as one hundred. Only of the Todas did he measure so many as 82 ; of 19 other samples the number lies between 50 and 60, and the remaining 59, out of the 79 tribes or castes measured by him, have less than 50 individuals each, and 11 of

[1] *Journ. Asiat. Soc. Bengal*, 1900, Part III, p. 73.
[2] *Journ. Asiat. Soc. Bengal*, 1893, Part III, Appendix, p. 1.

these again go down below 25. Then again, Thurston has given only the average values and not the individual measurements themselves, so that for scientific analysis his record is not of much worth.

Risley's samples are much better in size: one goes up to 185, 35 lie between 100 and 109, and 21 between 50 and 99; but the remaining 30 series are too small, and 14 of them go down even below 20. Though some of his samples are fairly large, quite a large number of them are of inadequate size. Risley could certainly have improved the size of his samples.

Above all, however, it has to be borne in mind that the entire mass of anthropological data thus collected was too inadequate to determine with any degree of accuracy the racial composition of 353 millions of peoples, speaking 225 different languages apart from dialects, scattered over an area of eighteen hundred thousand square miles, 'greater by 12,100 square miles than the whole of Europe excluding Russia proper, Poland and Finland' (as Risley himself points out [1]), and at the same time divided into races, tribes, castes, sub-castes and sects that make up a thousand or more endogamous groups that do not intermarry. For determining the racial constitution of the Swedish people, forming a fiftieth part of the total population of India, Retzius and Fürst, in the closing years of the nineteenth century when Risley was collecting his materials, proceeded to work on the measurements of 46,000 individuals, and yet again H. Lundborg and F. J. Linders found it necessary to revise the data by fresh measurements taken on 47,387 subjects, that is, almost the half of the male population of Sweden between the ages of 20 and 22.[2] For about a tenth of the population of India, Livi. working about the same time as Risley, obtained his average cephalic index of the Italian peoples from head-measurements taken on 294,271 individuals, and for his stature averages he requisitioned a total of 1,350,799 subjects.[3] In comparison with the abundant material thus available for these and other European countries, the Indian data thus far collected sink into insignificance.

From this scanty and inadequate anthropometric material Risley proceeded in the Census Report of India for 1901 to formulate his sevenfold classification of the Indian peoples. Besides the three racial types distinguished by him earlier—the Aryan, the Dravidian, and the Mongoloid—Risley determined three mixed types, the Aryo-Dravidian, the Scytho-Dravidian, and the Mongolo-Dravidian, supposing that they arose from a blending or mixing of two out of the former three varieties. Moreover, he proposed a seventh type, the *Turco-Iranian* which as a racial designation was rather unhappy, implying, as it did,

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1 *Census Report of India*, 1901, I, p. 12.
2 *The Racial Characters of the Swedish Nation*, 1926.
3 *J.R.A.I.*, 1918, xlviii, pp. 81-82.

that the Turc and the Iranian represented two primary stocks of mankind. This classification has been assailed on all sides and been rightly rejected by anthropologists, though it makes its appearance in writings by non-anthropologists and misleads the lay reader. Risley's description of the round-headed people on the North-Western Frontier as Turco-Iranian stands condemned by its very name as we have already seen, and it does not indicate a correct delineation of their physical features; the people of Eastern India, of Bengal and Orissa he called Mongolo-Dravidian, although they have none of the characteristic Mongoloid features; the inhabitants of the western littoral and Coorg he designated Scytho-Dravidian, supposing that the Scythians had Mongoloid features, which most probably they had not, and besides, the Scythians had never penetrated so far to the south as Coorg, nor was their occupation of Kathiawar and the Konkan coast of sufficient duration to have produced any lasting influence upon the physiognomy of the people. The Indo-Aryans he confines to the Punjab, Rajputana, and the Kashmir valley, although speakers of Aryan languages occupy in India a vast area outside this tract, and the people of the Kashmir valley he would have found to belong to a different type if he had only measured them. The type-names *Aryo-Dravidian* and *Dravidian* are no more exact than the others. In the Dravidian type Risley includes all the peoples from the Vindhyas to Cape Comorin and from the Aravalli Hills to Rajmahal. Many of these peoples do not speak languages of the Dravidian stock at all, and the physical features of a large number of them are quite distinct from those of the Dravidians proper. Long ago Sergi and Deniker had already pointed out that Risley's Dravidians comprised two distinct types, one with a long head, a medium stature and a narrow (leptorrhine or mesorrhine) nose, and the other, also with a long head but having a short stature and a wide nose. These two types are quite distinct in their physical features, in their culture, and in their origin.

The second type referred to above has been called Pre-Dravidian by some, but this name, coined from the theory of their arrival in India before the Dravidians, has been found to be quite unsatisfactory. This people, who are perhaps rightly considered to form the basic substratum of the whole Indian population, offers us our first great problem of racial classification. We are not yet quite sure about their distribution in India itself, about their affinity with other peoples outside India, and about their origin, and the worst of it is that our information about them is very scanty. Their languages have not, for the most part, been properly studied, and very few anthropometric measurements have been taken amongst them. Anthropologists have to fall back upon Thurston's averages which, as we have seen, are so very inadequate, and in many instances worthless

for scientific analysis. Only four tribes of Southern India have been carefully measured in connection with the last Census by a competent anthropologist, Dr. B. S. Guha.

Owing to Risley's misapplication of the name Dravidian to peoples belonging to different racial stocks, the greatest confusion prevails in anthropological writings about the peoples of Southern India. The Dravidians of one writer are included among the Pre-Dravidians of another; when reading the writings of early authors like Huxley or Sir W. Turner, or of present-day workers like Morant, or even of Malone and Lahiri who published the results of blood tests of 589 Dravidians in 1928, we often have grave doubts to which of the two South Indian types their Dravidians belong. The Dravidians of Haddon are not exactly the Dravidians of Giuffrida-Ruggeri. Dr. J. H. Hutton, who has made a serious attempt in the latest Census Report to provide a new classification of the peoples of India consistent with our present knowledge about them, has not been able to clear up this Dravidian-Pre-Dravidian tangle, but he has made confusion worse confounded by using, at the suggestion of Colonel Sewell, a fresh designation, *Proto-Australoid*, for the primitive peoples of India, when their affiliation with the Australian people has not been placed beyond all doubt. Zuckerman, in his Bulletin on the Adichanallur skulls, makes it quite clear, by quoting almost all the reliable authorities who have dealt with South Indian craniological material, that 'craniological evidence derived from the present populations of the Dekkan does not support the hypothesis of a Pre-Dravidian racial stock whose representatives are, amongst others, the Australians, the jungle tribes of Southern India, and the Veddahs of Ceylon. It is difficult, however, to decide whether craniological evidence is a fundamental criterion of race; if it were, the hypothesis of a common stock for the jungle people of the Dekkan and the aboriginals of Australia would be untenable' (p. 19). Then again, Sewell's theory adopted by Hutton, of the origin of the Pre-Dravidians from Mesopotamia, and ultimately from the Palestine Man, on the authority of the Kish skulls, stands condemned by the great difference in the nasal index between the Kish skulls (N.I. 44·4) on the one hand, and the skulls of Indian primitive types—Veddah (N.I. 52·7), Adichanallur (N.I. 51·62), and the Veddaic skulls at Mohenjo-Daro (N.I. 51·06). The Al-U'baid skulls (N.I. 49·2) which Sewell requisitions as a connecting link between Kish and the Indian skulls, have entirely to be left out of this series as there is no trace in them, according to Keith, of alveolar prognathism which is a common feature of the Kish and the Indian skulls. In the light of these facts, Sewell's theory, adopted by Hutton without question, 'of the derivation of the Proto-Australoid type in India from a leptorrhine western type through a series of climatic modifications' (Census Report, 1931, I, p. 443), is far from convincing. Perhaps

we have to look for their origin to the East, to *Homo primigenius soloensis*, constituted from two skulls recently discovered at Ngandong in Java (Oppenoorth, W. F. F.: *Homo Javanthropus Soloensis.* Een Plistoceene Mensch van Java, 1932); such an alternative theory would solve many of our problems, but no sound theory can be formulated until we have more anthropometric material derived from an extensive series of measurements, both of skulls as well as of the living. Besides, numerous Palæolithic artefacts that can easily be graded into several stages of development have just now been discovered in Kashmir by the members of the Yale University expedition, and we have to wait expectantly for their report. Let us hope that they will light upon some skeletal material which is as yet wanting. Moreover, Mr. Mackay has dug up a number of skulls very recently in early strata in the Indus Valley. An attempt should also be made to dig up the graves still waiting to be excavated at Adichanallur itself.

The affinity of the South Indian primitive people with the Veddhas of Ceylon is unquestioned, and therefore I would propose that they be simply styled *Veddaic*, to save confusion, at least until we have a clear comprehension of their composition.

Risley's Dravidians require to be divided still further: the primitive tribes of Chota Nagpur who have been called *Kolarians* by some writers, appear to have distinct features distinguishing them from the Veddaic tribes further south, and should be placed in a class apart. Haddon, who places them in the Pre-Dravidian racial group, points out, 'There is something in the facial appearance of many Kolarians which enables an observer to pick out a typical inhabitant of Chota Nagpur from a crowd of southern Dravidians' (*Races of Man*, 108).

There is a still further problem that has risen with regard to the racial composition of the Dravidians proper, that is, the non-primitive speakers of Dravidian languages. Thurston's averages, meagre as they are, had already shown the presence of two racial types among them—one long-headed and the other round-headed, and this has become very clear from the measurements taken by Dr. B. S. Guha in connection with the last Census. The brachycephals among them appear to possess the same physical features as the Aryan-speaking brachycephals of Eastern and Western India. Elliot Smith had pointed out in his *Essays on the Evolution of Man* (1927) that one of the Adichanallur skulls sent to him for examination 'conforms more nearly to the racial type that is known as Mediterranean, which is so largely represented in the present population of India' (p. 130), but in a note appended to Zuckerman's Bulletin on the Adichanallur skulls (1930), he adds, 'It is not of pure Mediterranean type, the breadth of the cranium and the flattening of the occiput suggesting the possibility that it may be an example of the type I have called 'Maritime Armenoid', a branch of the

Alpine Race that is found as one of the ingredients of the racial mixture known as Dravidian' (p. 1).

After the elimination of the Veddaics and the Alpines from the speakers of the Dravidian languages we get a remnant of dolichocephals with a narrow nose and medium stature who have been defined as the Dravidians proper by Haddon; but the problem is, should we call this type by a linguistic name at all? Did they speak a Dravidian language when they first entered India, or did they assume it in Southern India? They have been supposed to have been the most numerous at Mohenjo-Daro, but the writings there have not been read yet and we know nothing as to what stock the language belonged; whether it had anything to do with the Dravidian language is doubtful, the script itself having various degrees of affinity with ancient scripts from Crete to Easter Island. We may call this type the Indo-Mediterranean Race from its apparent affinity with the Mediterraneans, taking out from its appellation the factor of language altogether, or, better still, we may call it 'the Brown Race' with Elliot Smith. Their distribution does not appear to be confined to the Dravidian-speaking region at all, but it seems that side by side with the non-Mongoloid narrow-nosed brachycephals of medium stature they are distributed over a very wide area in this country.

In Bengal, for example, the presence of the brachycephalic Alpine and the dolichocephalic Veddaic types has been fairly well established, but the existence in that province of the slender, long-headed, fine-nosed Mediterranean type has not been so very clear, and hence I would proceed to examine this problem in some detail, as the case of Bengal will provide us with a typical illustration for other parts of India where the Alpine brachycephals predominate. I have lately measured a hundred individuals of one of the high castes, the Rāḍhi Brahmins of Bengal, and a hundred of the Muchis of the district of Birbhum in the same province, occupying the very lowest rung of the social ladder, and besides, some of the other high castes—the three groups of Kayasthas that we find in the country and also of the Vaidyas. As the Kayasthas and Vaidyas differ but little from the Brahmins, I have kept them out of consideration for the present, and would compare the Brahmins with the Muchis. I have throughout followed the directions of Martin in my measurements as laid down in the second edition of his Lehrbuch, and I have indicated the particular measurement taken by quoting the number given to each in his book. I took 60 measurements on the head and different parts of the body and have derived 54 indices from them. Besides, I have recorded the results of my visual observation of 31 features that are mostly non-measurable. I have tried to include most of the important measurements and indices recommended by Martin. The statistical treatment of this rather large number of

measurements, indices and observations, it has not yet been possible to take up, for shortness of time, as they were taken in October and November last; but I have worked out the arithmetical means for the purposes of comparison of the Brahmin with the Muchi, and have set them forth in a table given at the end. I have also given in another table some specimen pages from my record of observations and measurements on 25 Brahmins in order to show my method and technique. The whole record may be published by the Calcutta University later. From the first table I have brought here together only four averages for our immediate use, and have also indicated in another short table the percentage composition of the Brahmin and the Muchi with regard to stature and the forms of the head and the nose.

TABLE I.

	Average Stature.	Average length-breadth Index of head.	Average length-height Index of head.	Average Nasal Index.
Brahmin ..	1658·97	82·25	69·99	64·28
Muchi ..	1615·79	79·22	65·70	68·98

TABLE II.

	STATURE.			LENGTH-BREADTH INDEX OF HEAD.			LENGTH-HEIGHT INDEX OF HEAD.			NASAL INDEX.		
	Short.	Medium.	Tall.	Dolichocephal.	Mesocephal.	Brachycephal.	Chamaecephal.	Orthocephal.	Hypsicephal.	Leptorrhine.	Mesorrhine.	Platyrrhine.
	%	%	%	%	%	%	%	%	%	%	%	%
Brahmin	32	36	32	9	44	47	2	10	88	68	32	0
Muchi ..	69	22	9	15	53	32	4	17	79	55	42	3

It will be observed from the above tables, that while the Brahmin has a brachycephalic average head index, the Muchi has a mesocephalic one, and from the analysis in Table II it

is seen that while there is a preponderance of brachy- and meso-cephals in both, there is a certain proportion of dolichocephals in them, and that it is higher in the Muchi than in the Brahmin. It will also be observed that chamaecephaly, which is a Veddaic feature, is present in a very small percentage (2 and 4 respectively) in the two groups which are predominantly hypsicephalic.

Among the Brahmins measured by me, there is not a single platyrrhine individual, while among the Muchis there are only three in a hundred, and the average nasal index is well within the range of leptorrhiny in both, the Brahmin nose being a little finer. In stature, the averages show that while the Brahmin is of medium height, the Muchi is below the medium, but as this comparatively low stature is associated with a fine nose, the dolichocephalic racial element that enters into the composition of both is not the Veddaic but the Mediterranean. The Veddaic element has but slightly affected the composition of the Muchi, while it is almost absent in the Brahmin. It is thus clear that beside the Alpine element which is strong in both, and more so in the Brahmin than in the Muchi, the Mediterranean element is present in both but more prominent in the Muchi than in the Brahmin.

We find from Giuffrida-Ruggeri's '*Sketch of the Anthropology of Italy*' (J.R.A.I., XLVIII, 89) that in the five southern districts of Italy, where the Mediterranean type is predominant, the average stature ranges between 1604 and 1620, the average cephalic index lying between 78·4 and 82·1 and the nasal index between 69·49 and 69·77, the homogeneity of the type being seen in the nasal index. He describes the people of the region as of a height generally below the medium, the skin somewhat brown, the hair and eyes black, and having a slim figure without adipose and without a paunch. The slender figure without adipose and without a paunch is a general character of the Muchi, and of a considerable number of the Brahmins; Elliot Smith's description of 'the Brown Race' of which he notes that the whole skeleton is of slight build and suggestive of effeminacy, fits in very well with general Bengali physiognomy. Among the hundred Muchis measured by me there were only two individuals of the stout, thick-set, stocky figure that is generally associated with the Alpine type, and though the percentage of this latter type is a little higher in the Brahmins, the girth measurements will show that it is not high in any group of Bengalis. Elliot Smith also notes about the Brown Race that it is marked by scanty hair on body and face; this is also a general character of the Muchi among whom I find, from my observation tables, that about 90 per cent. have very scanty hair on the body, and the hair on their lips and chin is not very plentiful. Among the Brahmins also I noticed a fair number having very scanty body hair, though on the face it is comparatively thick in the majority.

From an analysis of these two castes of Bengal we perceive the existence of a predominant Alpine type and of an appreciable Mediterranean or Brown Race type among the Bengalis, and it seems reasonable to expect that the presence of these two types in varying proportions may be discovered on a similar analysis being made in many other parts of India, but the somatometric data at present available are too scanty to arrive at any definite and exact conclusion.

Mr. A. E. Porter in the last Census Report for Bengal (§459) refers to the wide divergence between the Brahmins of Bengal and Mithila; but the 53 Maithil Brahmins I measured, mainly of the Darbhanga district and a few from the Mozaffurpore district, show a considerable affinity between the two, with a fair percentage of brachycephals among them; but a series of 85 Bhumihars whom I measured in the interior of the Patna district show a lower percentage of brachycephals among them, as will appear from the following table:—

	Stature.				Cephalic Index.				Nasal Index.			
	Average.	Short.	Medium.	Tall.	Average.	Dolichocephal.	Mesocephal.	Brachycephal.	Average.	Leptorrhine.	Mesorrhine.	Platyrrhine.
		%	%	%		%	%	%		%	%	%
Maithil Brahmin	1634	25	64	11	78·20	23	58	19	66·6	66	34	0
Bhumihar	1644	25	55	20	76·6	42	47	11	69·0	58	40	2

Prof. Eickstedt in his classification of the peoples of India (*Zeitschrift für Morphologie und Anthropologie*, XXXII. 77ff.), has not taken the brachycephals into consideration at all, in fact he has attached little importance to the cephalic index in formulating his scheme. His analysis of the Indian peoples, however, is a brilliant piece of work, wherein he studies the Indian racial problem from an entirely independent point of view, and let us hope that he will work it out more fully and help us to disentangle our knotty problems, as his exhaustive knowledge of all departments of anthropology eminently fits him to do.

I shall next proceed to a discussion of the problem of Aryan migration into India. It has been widely held that Vedic Aryan culture was introduced into India by the tall, long-headed branch of the Indo-European people, the so-called *Proto-Nordic* race, and Dr. Hutton in the last Census Report has exercised

great ingenuity and skill to establish this thesis. But a sifting examination, unbiassed by the Nordic obsession, of the anthropological data, as well as of the evidence afforded by the Vedic literature itself, goes to prove that the Alpine brachycephals have as great, if not a greater share, in the development and propagation of the Aryan language and of the Vedic religion.

A stock argument advanced in favour of the Proto-Nordic introduction of Vedic culture into India is that the tall long-heads now occupy the country through which flow most of the rivers mentioned in the Rigveda, the fact being quite lost sight of that they were comparatively late arrivals. The very position of these long-headed people in India, surrounded as they are on almost three sides by the Alpine round-heads, shows that they forced their way through the mass of the earlier Alpine settlers, who spoke and do speak at the present day as good Aryan dialects as the so-called Proto-Nordics. Then again, certain texts have been quoted from the very late Vedic literature to prove that the Alpine dwellers of Eastern and Western India were regarded as un-Vedic, but certainly this was not true of the early Vedic period at any rate. Moreover, it has been held that throughout the long centuries through which the Rigvedic hymns were composed, the Vedic Aryans confined themselves to the Punjab without moving towards the east or the south. That the Aryan-speaking people, who were mostly nomads who had domesticated the horse, would sit tight in a corner of India while the vast fertile plains lay open before them for a thousand miles without any serious geographical obstacle, is absurd on the very face of it, and I appeal at first instance to the Rigveda itself to dispel this illusion.

We are told by a hymn in the Rigveda (x. 136) that long-haired, yellow-robed ascetics bearing the designation of *Muni*, traversed the whole width of India from the Eastern to the Western Ocean—from the Bay of Bengal to the Arabian Sea. Thus we read in the hymn—'The Muni who is (verily) the steed of the wind and is the comrade of Vāyu, the Wind-God, being urged on by the gods, *travels to both the oceans, the Eastern as well as the Western*' (verse 5). Moreover, the country of the *Kîkaṭas* which from later Indian literature we know to have included modern Behar, was well known to the Rigveda (III. 53, 14).

Bringing together all the characteristics enumerated in the Rigvedic hymn in which the above verse occurs, we observe that the Muni is described there as wearing long hair (*keśin*) and as garbed in dirty-looking brown garments, and it is thus clear that he is the predecessor of the later *Yati* or *Parivrājaka*, and, like him, his business is to wander from place to place, wearing long unkempt hair, robed in yellow or brown vestments, spreading the culture and religion of the Veda, and the worship of the gods, of each of whom he has thus become a devoted friend (*sakhā*

hitaḥ); by his intense love of and devout service to the gods he is often thrown into a condition of ecstasy when his body shakes and trembles like a tree with the wind (*Munirdhunirva*), as the Rigveda (VII. 56, 8) has it. The Munis travel with the swiftness of the wind and wander through the wilds and forests following paths trod only by wild beasts. The *Muni* with his constant peregrinations and devout service to the gods is invested with superhuman and mystic powers, so much so that the long-haired *Muni* is believed to be a comrade of the dreadful god, Rudra, with whom he drinks from the same cup of poison, as a verse of the same Muni-hymn informs us (Rv. X. 136, 5–8).

The character, with which the Rigveda invests the Muni, is associated with him throughout the Vedic literature, and we find him as one of the earliest preachers of Vedic religion and culture. He is a live creature well known to Indian tradition, and cannot be explained away as a mere mystic reference to the Sun, as some scholars have tried to do.

Moreover, it may be pointed out that though the Rigveda does not mention the Eastern and the Western Oceans in any other passage than the one we have quoted, yet it refers to the *chaturaḥ samudrān* (Rv. IX, 33, 6). 'the four oceans', showing that it was known to the Rigvedic seers that land was girt by sea in every direction, just as the *Aitareya Brāhmaṇa* (VIII. 25, 1) says that the ocean envelops the earth.

Then again, the Western and the Eastern Oceans are mentioned in Vedic literature in passages where there is very little room to doubt an intimate knowledge of the two seas among the Vedic Aryans. Two passages in the Śatapatha Brāhmaṇa (I. 6. 3, 11 and X. 6. 4, 1) speak of the Eastern and Western Oceans in exactly the same words used in the Rigveda to designate the two seas—viz. *Pūrva* and *Apara Samudra*. Referring to these two passages the authors of the Vedic Index (II. 433) also observe, 'The eastern and western oceans in Śatapatha Brāhmaṇa, though metaphorical, probably indicate an acquaintance with both seas, the Indian Ocean and the Arabian Sea'. There can, therefore, be no doubt that the Rigvedic verses, mentioning the same seas in exactly the same words, *Pūrva* and *Apara Samudra*, must indicate that in the Rigvedic Age the Indo-Aryans had got acquainted with them. Bühler pointed out long ago that the numerous passages in the Rigveda referring to the story of the saving of Bhujyu by the Aśvins in their hundred-oared vessel, may indicate his rescue from shipwreck while on a voyage in the Indian Ocean. The Atharvaveda (XI. 5, 6) also tells us that the celibate ascetic (*Brahmachārin*), clothed in the skin of the black antelope, and wearing a long beard (*dīrgha-śmaśru*) wanders from the Eastern to the Northern Ocean.

In the next succeeding age, when the Kalpasūtras were composed, and which must have been separated from the Brāh-

maṇa epoch by several hundred years, we find that differences in custom and conduct had arisen in the different Vedic divisions, separating them from the people of the Vedic Midland which formed the centre of later Vedic culture; and we find purist champions of the Midland culture deprecating the people on the frontiers, in the east, west, or the south. Thus Baudhāyana declares, 'The inhabitants of *Avanti* (or *Ânartta* according to a difference in reading), of Aṅga, of Magadha, of Saurāshṭra, of the Deccan (Dakshiṇāpatha), of Upāvrit, of Sindh, and the Sauvîras. are of mixed origin. He who has visited the (countries of the) Âraṭṭas, Kāraskaras, Puṇḍras, Sauvîras, Vaṅgas, Kaliṅgas, (or) Prānūnas, shall offer a Punastoma or a Sarvapṛishṭhā (Ishṭi)' (Dharmasūtra, 1, 2, 12-13). In his Śrautasūtra (XVIII. 13) also Baudhāyana prescribes similar penances. the Chatushṭoma Agnishṭoma for those who visit the above countries, and Âpastamba in his Śrautasūtra (XXII. 6, 18) too prescribes the Ekaviṃśa-stoma for one guilty of a similar misconduct. Thus he ordains, '(The penance for an individual is) the Ekaviṃśa when he goes to a people such as the Gāndhāris, Kaliṅgas, Magadhas, Pāraskaras (or Kāraskaras), or the Sauvîras'. Hiraṇyakeśin in his Śrautasūtra (XVII 6) delivers himself in the same strain. Very late writers on the Dharmaśāstra also have indulged in similar condemnations in imitation of the Kalpasūtra; thus Devala (Smṛiti. verse 15) says, 'A person requires to go through a purificatory rite by visiting the (countries of) Sindhu, Sauvîra, and Saurāshṭra, and the peoples inhabiting the frontier regions and the Kaliṅgas, the Koṅkanas and the Vaṅgas'. Another verse in the same tenor is often quoted: 'A person who visits the countries of Aṅga, Vaṅga, and Kaliṅga, or those of Saurāshṭra and Magadha except for the purposes of pilgrimage requires to go through a ceremony of purification (or, to be initiated anew)'.

Now, it will be observed that the countries thus condemned include Gujarat, Kathiawar, and Konkan in the south-west, Sind and a great part of the Punjab and the North-Western Frontier, Bihar, Bengal and Orissa, and the whole of Southern India (Dakshiṇāpatha), that is, almost the whole of India leaving only a narrow strip in the Midland, the Doab between the Ganges and the Jumna, the country within the narrowest limits of the so-called Âryāvarta as defined by Baudhāyana and Vasishṭha, both of whom give two alternative definitions of it. Thus says Baudhāyana (Dh.S.I. 1, 2, 9-10): 'The country of the Âryas (Âryāvartta) lies to the east of the region where (the river Sarasvatî) disappears, to the west of the Black-forest (Kālakavana), to the north of the Pāripatra (mountains, i.e. the Aravallis), and to the south of the Himālaya. The rule of conduct which prevails there is authoritative. Some declare the country between the (rivers) Yamunā and the Ganges (to be the Âryāvartta)'. This latter view perhaps represents the personal

view of Vasishṭha and Baudhāyana, but both of them have the goodness to give a third alternative which provides a far more liberal definition of the region where Vedic culture prevails, and which is quoted from a *gāthā* or verse of the *Bhāllavins*, an ancient Brāhmaṇa school of the Sāmavedins whose works are no longer extant. Thus Vasishṭha (Dh.S. I. 13–15): 'Others (state) as an alternative, that spiritual pre-eminence derived from a study of the Vedas is found as far as the black antelope grazes. Now the Bhāllavins quote also the (following) verse in the Nidāna: "In the west, the boundary is the Sindhu (the Ocean, or the Indus), in the east the region where the sun rises,—as far as the black antelope wanders, so far (is found) spiritual pre-eminence acquired from a study of the Vedas".' Baudhāyana (Dh.S. I. 1. 2, 11-12) also rounds up his discussion about the limits of Aryāvarta with exactly this quotation from the Bhāllavins. The importance of the black buck or Indian antelope (Krishṇasāra) to Vedic culture may be seen from numerous passages in Vedic literature: 'The skin of the black antelope is the visible form of the Brahman', that is, of the Veda, declares the *Taittirîya Saṃhitā* (V. 4. 4, 4), and the *Tāṇḍya Mahābrāhmaṇa* (XVII. 11, 8) asserts that Krishṇājina is the visible form of *Brahmavarchas*, that is, of spiritual pre-eminence as acquired by a study of the Vedas. It is evident, therefore, that in the age of that Brāhmaṇa, the Vedic Aryans had wandered far and wide through the Indian continent, following the black buck wherever it roamed, '*mrigāṇām charaṇe charan*' as the Rigveda (X. 136, 6) puts it, and that Vedic Aryandom had become conterminous with the range of the Indian Antelope, *Oryx cervicapra*, because, as Blanford observes, the genus to which it belongs is peculiar to India where its range is very wide. 'This antelope,' says Blanford, 'is found in suitable localities, chiefly open plains with grass of moderate height, from the Indus to Assam, and from the base of the Himalayas to the neighbourhood of Trichinopoly. Formerly it was far more abundant, and in the first half of the nineteenth century it was seen occasionally in vast herds of 8,000 to 10,000 in number; but its numbers have been greatly reduced since rifles have become common.' (*Imp. Gaz. of India*, I, 235).

Now, the question is, what is the reason of this threefold definition of Vedic Aryandom. The question as to how far the Âryas dwelt in the east or the west cannot be a matter of opinion, but is a matter of fact. It is absurd to imagine that the Âryas who, at the early period of the Brāhmaṇa work of the Bhāllavins, dwelt from the Arabian Sea up to the plains of Assam, had receded in later times within the Ganges-Jumna doab; the only inference that can be drawn is that the Âryas, living in the far east, as well as the extreme west, were developing customs and manners that differed from the ancient traditions of the Vedic Aryans as preserved in the Midland, and that in the Midland itself people had worn off the expansive

energy and elasticity of the Vedic Aryans in their pristine vigour, and were growing stagnant, developing a narrower outlook towards life in general and developing an exaggerated idea of their own customs and practices that were fast growing fossilized. If the people on the west—in Konkana, Ânartta, Saurāshṭra, Sind and the Punjab on the western front, and Vaṅga and Kaliṅga on the eastern, were deviating from the ancient traditions, the Midland purists felt disinclined to recognize them as their own kith and kin. There were purists of a still narrower type represented by those who held the second alternative limiting the Âryas to the thin strip of land between the Ganges and the Jumna, leaving out every other people, north, south, east and west. These are the purists of the doab, perhaps younger contemporaries of Vasishṭha and Baudhāyana, who glorying within the two sacred rivers were cultivating an aloofness from the rest of India. It should be remarked, however, that the ancient traditions of the Brāhmaṇa times, making Vedic Aryandom conterminous with almost the whole of India, were not entirely forgotten; in fact, the statements of Manu and Yājñavalkya with regard to the limits of Vedic India show that they survived till a very late age. Moreover, it requires to be particularly recognized that the word '*Ârya*' in Vasishṭha and Baudhāyana has no ethnic significance at all, but is almost synonymous with '*śishṭa*', that is, 'a man of correct conduct', as appears from the context, and Patañjali in his discussion about the 'Śishtas' in the Mahābhāshya (on Pāṇini VI. 3, 109), gives a definition of the śishṭa-land in almost the exact words of the above two authors of the Dharmasūtras.

The reasons from which the strong feeling against the frontier provinces in the east and the west had its origin, may be discovered in these Sūtra works themselves. Baudhāyana, for example, in his Dharmasūtra (II. 1, 2) while enumerating the offences that constitute a transgression entailing a 'fall' (*patanîya*) or degradation from social position, gives first rank to 'going to the sea' (*samudra-saṃyānam*), and includes trade and commerce in the same list. Thus says he: 'Now (follow the offences) causing loss of caste (*patanîya*), (viz.) making voyages by sea, stealing the property of a Brāhmaṇa or a deposit, giving false evidence regarding land, trading with merchandise of any description (whether) forbidden or not, serving Śūdras, etc. For those who have committed one of these (offences the following penance is prescribed): "They shall eat every fourth mealtime a little food, bathe at the time of the three libations, morning, noon and evening, passing the day standing, and the night sitting. After the lapse of three years they throw off their guilt".' In the very first chapter of his Dharmasūtra also Baudhāyana complains against the irregular practices of the people of Northern India, such as going to sea, trading in wool, or in animals like the horse (that have teeth in the upper and the

lower jaw), and following the trade of arms, and we have seen what severe punishment he ordains for sea-voyage and trade of any kind. Is it any wonder that law-givers like Baudhāyana, who profess such a great horror against sea-voyage and trade, should condemn maritime countries like Sindhu, Saurāshṭra and Ânartta on the western coast, and Vaṅga and Kaliṅga on the eastern?

Baudhāyana, in the passage from his Dharmasūtra quoted above, speaks of the people on the western and eastern frontiers as of mixed origin (*sankîrṇa-yonayaḥ*). Perhaps he means that the people in these provinces had got mixed up with non-Aryan elements; admixture had taken place everywhere in India with the earlier non-Aryan ethnic strata—the aboriginal inhabitants and the Mediterraneans, some of whom they displaced, but many of them they must have absorbed; and besides, there must have been an admixture of culture in the frontier province owing to the people coming into contact with the foreign nations they traded with. Quite apart from this, however, the ethnological survey of the Indian peoples has discovered that there is a clear ethnic distinction between the people of the Vedic Midland, including the Eastern Punjab, Northern Rajputana, and the western districts of the United Provinces, on the one hand, and the countries on the eastern and western frontiers which Baudhāyana condemns, on the other, just the same distinction as between the peoples of Northern and Southern Germany. While the people of the districts included in the Midland are predominantly long-headed, the round-heads are found predominant in almost all other parts of Aryan-speaking India, as Dr. B. S. Guha's measurements have shown.

There is also a difference in the languages spoken by these two groups of peoples in India, as was pointed out long ago by Hoernle and this has been confirmed by the Linguistic Survey of India carried on under Grierson. It is found that they fall into two distinct branches of the Indo-European family, that the languages spoken in the outer or peripheral area, viz. Lahnda or Western Panjabi, Sindhi, Marathi, Oriya, Bihari, Bengali, and Assamese, which may be called the 'Outer Branch', are derived from a different dialect of the original Indo-European tongue than the languages of the 'Inner Branch', viz. Western Hindi, Panjabi, Bhili, Khandeshi, Rajasthani, and the Pahari dialects.

Now, the question is, which group entered India earlier. Grierson observes, 'At an early period of the linguistic history of India, there must have been two sets of Indo-Aryan dialects—one the language of the Midland, and the other, the group of dialects forming the Outer Band. From this it has been argued, and the contention is entirely borne out by the results of the ethnological enquiries, that the inhabitants of the Midland

represent the latest stage of Indo-Aryan immigration. The earliest arrivals spoke one dialect, and the new-comers another. According to Dr. Hoernle, who first suggested the theory, the latest invaders probably entered the Punjab like a wedge, coming into the heart of the country already occupied by the first immigrants, and forcing the latter outwards in three directions to the east, to the south and to the west' (Imp. Gaz. of India, Vol. I, pp. 357-9).

It is now generally accepted that these Aryan-speaking round-headed peoples entered India from the Pamirs, as Chanda was the first to point out, but he held that they represented a later wave of immigration than that of the long-heads. But Giuffrida-Ruggeri and Dixon think that the round-heads were the first to enter. Hutton, in his Census Report of India (1931, Vol. I, pp. 449ff and pp. 366-369), also accepts unreservedly that the round-headed immigrants came first, but he sticks to the idea that the Rigvedic culture originated among the long-headed peoples who entered India later; he fails, however, to adduce any evidence in support of his theory. There are no means of ascertaining whether the Rigvedic Aryans were long-headed or round-headed; perhaps there was already a mixture of these two types of the Indo-European race before they entered India. At Mohenjo-Daro distinctly round-headed Alpine skulls (Type IV of Guha and Sewell) have been found, beside Veddaic, Mediterranean and Mongoloid skulls, but none of the type to which the tall, long-headed people of the Midland might be apportioned. The descendants of the Alpine round-heads whom we thus find in India in very early times, speak at present pure dialects derived in a direct line of descent from the Rigvedic tongue, and we have demonstrated that the Rigvedic Aryans had already spread over the portions of India which the round-heads now occupy in the south-west and the east. It would, therefore, be quite natural to conclude that the round-headed Alpines, having been the first immigrants of Aryan speech into India, should presumably have been the first originators of the early Vedic culture also, at least they must have been the predominant type among the early Vedic Aryans. In later times large numbers of peoples, belonging to the long-headed branch of the Indo-European race, and speaking a different dialect, came pouring in through the north-western passes, and drove the more cultured, and hence, less warlike, round-heads towards the south and the east, and wrested the Punjab and the Midland from them. These comparatively barbarous and warlike newcomers, belonging to a collateral but different branch of the Indo-European stock, viz. the Proto-Nordic, gradually absorbed the Vedic culture of the earlier settlers. As a result of the compact of these two types, the earlier inspired and poetic style of the hymns gave rise to the vigorous prose style of the Brāhmaṇas, and the

subsequent Vedic culture developed and flourished in the hands of this new people. These Proto-Nordics, averse at first to trade and a sea-faring life, stuck fast bigotedly to the customs they had adopted and disliked the new customs that the round-heads whom they had pushed south, and east, were developing in their new envircnment. Hence their strong feeling against going to sea and the condemnation of countries like Gujarat and Mahārāshṭra on the one hand and Bengal and Orissa on the other, where the people naturally took to maritime intercourse and trade with foreign peoples, with the islands in the Indian Ocean and with China.

It is thus clear that in these passages of the very late and subsidiary Vedic literature there is nothing to show that the peoples in Eastern or Western India were un-Aryan. On the other hand there is every reason to believe that the brachymorphous Indo-Europeans speaking Aryan languages had settled in Northern India and spread as far as the Tinnevelly district in the extreme south at a very early period, as the Adichanallur skull examined by Elliot Smith shows. Engulfed in the ocean of speakers of Dravidian languages who perhaps under the pressure of these very Alpine invaders had become concentrated in the south, they lost their language, but perhaps imparted at least some elements of their culture to them even at that early epoch.

At the present day we find small groups, mere islands of peoples bearing Indo-European features, isolated in the wild regions that extend from the north-eastern frontier of India to the Pacific. The fact that they extend almost in a continuous line from the borders of Assam eastwards to the ocean tends to prove that they passed from India, and thus must have crossed the whole width of Northern India to the Patkoi range and beyond. We often do not know much of their culture, but the very fact that most of them are at a primitive stage of culture would suggest that isolated in unfavourable surroundings they lost what culture they possessed, or that they passed through India in very early times before the development of Vedic culture in India. In that case, it would be premised that in Eastern India men of the Indo-European racial type had settled even before the rise of the Vedic civilization. But only an intensive study of these peoples, both of their physical features and of their culture, can definitely solve the problem of these stranded remnants of Indo-Europeans.

At every turn in our attempt to solve the problems of racial classification, we are faced with a dearth of adequate materials to work upon. In India, therefore, a vast field for work lies before the anthropologist for investigation. Even in Great Britain where a number of renowned anthropologists have worked for such a long time, an appeal has recently been issued (*The Times*, March 13th, 1935) over the signature of 20 gentlemen, mostly anthropologists, for money 'to set on foot a compre-

hensive survey of the past and present populations of Great Britain', pointing out that 'Britain has lagged behind many other countries in carrying out recognized research into the racial history and the present physical constitution'. These remarks apply with all the greater force to India where so little work has been done up to the present for solving the racial problems.

In India the number of independent groups with varying racial constitutions is so large that only a band of investigators working in each province for a number of years can hope to get together sufficient material for determining the racial history of the people. Theorization here must wait until a sufficient body of reliable materials has accumulated. We must know more of the constituent elements of the Indian people, before we can undertake their racial analysis or seek for their origin.

Then again, each caste or tribal unit must be examined over the whole range of its distribution. While measuring the Rāḍhi Brahmins in Calcutta and the Muchi in the Birbhum district of Bengal, I felt that the Rāḍhi Brahmins of the Birbhum district were not quite like the Rāḍhi Brahmins of Eastern Bengal and Calcutta whom I had been measuring, that the difference between the Brahmin and Muchi of Birbhum itself would not be so striking as the difference I discovered between the two groups of mine. The cephalic indices obtained from a measurement of the head from over ten thousand college students in Calcutta showed a great range of variation inside the same caste unit in different districts.

Another matter that I would bring to the notice of our anthropometric investigators is the number of measurements that have to be taken on each individual. Martin has set forth in his Lehrbuch the various measurements that the researches of anthropological investigators in various fields of work have shown to be necessary for an anatomical study of the human skeleton. He has described 71 measurements on the body and 49 on the head, all of which it is not always easy to take in the course of our field work, yet an attempt should be made to obtain as detailed a knowledge of the human anatomy as possible. Our earlier investigators have taken too few measurements. Thurston took only 5 measurements (comprising stature and the length and breadth of the head and the nose) in Southern India, which therefore remains practically unknown. Risley took 11 measurements (comprising stature, weight and 9 measurements on the head) besides 2 additional measurements on the head in a few cases. Dr. B. S. Guha, whose anthropometric work in connection with the last Census operations is the most substantial contribution to Indian anthropology since Risley, has measured 18 different characters supplemented by 20 visual observations on features that cannot be quantitatively determined. His work has also been the most extensive,

after Risley, as it embraced 51 racial groups from all parts of India. Prof. Eickstedt's measurements on 144 Punjabis held as prisoners by Germany during the Great War is the most intensive work that has as yet been published embracing 42 different measurements on the face and the body, 13 personal data and 25 somatoscopic observations; besides, he has calculated a fairly large number of indices in the case of 76 Sikhs included among the Punjabis. In my work on the Bengal castes I have measured 60 different characters on the head and the body, supplemented by 11 personal and 31 somatoscopic observations, and have besides calculated 54 indices. I have given here a specimen of my anthropometric record in the hope of rousing a discussion about the number of measurements with fellow-workers in India, as to whether this list requires to be augmented or reduced for actual field work. Dr. Guha has not taken the measurements on the body proportions, but these have acquired importance for racial analysis, as shown by the data collected by Martin. Another complaint that we have to make against Dr. Guha is that he has given us only the averages and not the individual measurements as Risley has done. Perhaps he reserves them for a subsequent volume. The size of the samples is another matter that requires attention. Some of our early samples were very small in size, and hence, as we have seen, not scientifically useful.

All anthropometric measurements require to be tested and treated by statistical methods in order to make our results scientifically exact and accurate. For the characterization of particular aggregates and for discovering their mutual inter-relation the statistical method is invaluable. It should be borne in mind at the same time, as Martin observes (*Lehrbuch*, p. 68), that the application of statistical methods should always be objective, for in itself it might provide mathematical relations capable of various biological interpretations.

The anthropometric work that has been done in India so far is only of the nature of a preliminary survey and has provided us with a superficial knowledge of a few only of the large number of independent groups in each province, and the time has now arrived for exact and intensive investigation on strictly scientific lines. The investigator has to make a choice of his own particular field of work in an area where the conditions are most favourable to him for intensive work, where the vernacular of the people he has chosen to study is known to him. We are all very grateful to the officials and missionaries by whom anthropological work has so long been mainly done in India, but we have to admit, as Rivers declares, that in spite of the many advantages of the position of the official and the missionary, and of the nature of their work which brings them into intimate contact with the people, 'the amount of work we owe to the two groups of persons is disappointing both in extent and in

scientific value' (*Report on Anthropological Work outside America*, Washington, 1913, p. 8).

The days of amateurish work, which have so often done harm to the growth of the science of anthropology, are gone, and trained investigators must now devote their whole time and energy to anthropological research, unhampered by other duties, to turn out scientifically exact and valuable work. Anthropology is a young science, and it should be approached with youthful earnestness and devotion.

TABLE SHOWING THE AVERAGE MEASUREMENTS (IN MM.) AND INDICES OF 100 RĀḌHI BRAHMINS AND 100 MUCHIS OF BENGAL.

	Horizontal Circumference of Head.	Longitudinal Arc of Head.	Transversal Arc of Head.	Maximum Girth of Upper Arm.	Girth of Wrist.	Girth of Calf.	Girth of Ankle.	Chest Girth.	
								Inspiration.	Expiration.
Rāḍhi Brahmin	539	348	343	247	151	325	200	880	848
Muchi ..	526	328	326	210	141	276	181	805	790

	Maximum Head Length.	Maximum Head Breadth.	Auricular Height of Head.	Total Height of Head.	Minimum Frontal Breadth.	Maximum Bizygomatic Breadth.	Bigonial Breadth.
Rāḍhi Brahmin	183·39	150·84	128·34	216·90	98·60	134·04	98·00
Muchi ..	179·00	141·57	117·42	206·98	98·97	128·57	92·57

	Physiognomic Total Facial Height.	Morphological Total Facial Height.	Physiognomic Upper Facial Height.	Morphological Upper Facial Height.	Nasal Height.	Nasal Breadth.	Nasal Depth.
Rāḍhi Brahmin	168·98	111·96	73·58	65·54	53·03	34·09	21·76
Muchi ..	170·69	113·96	69·60	60·98	49·88	34·41	19·96

	Interocular Breadth.	External Orbital Breadth.	Bi-Orbito Nasal Arc.	Labial Height.	Breadth of Mouth.	Physiognomic Length of Ear.
Rāḍhi Brahmin ..	29·90	109·84	128·40	16·38	48·70	60·12
Muchi	29·59	97·21	111·33	16·43	45·08	58·30

	Physiognomic Breadth of Ear.	Stretch of Arms.	Height Vertex.	Height Omphalion.	Sitting Height Vertex.
Rāḍhi Brahmin ..	32·96	1702·90	1658·97	1094·50	867·16
Muchi	33·49	1663·75	1615·79	950·24	802·05

	Trunk Length.	Shoulder Width.	Maximum Hip Width.	Total Arm Length.	Upper Arm Length.	Lower Arm Length.	Hand Length.	Hand Breadth.
Rāḍhi Brahmin	523·50	367·62	284·24	737·82	316·12	271·06	186·38	80·42
Muchi ..	486·46	534·31	254·35	672·66	315·66	249·41	182·35	81·30

	Middle Finger Length.	Foot Length.	Foot Breadth.	Total Leg Length.	Upper Leg Length.	Lower Leg Length.	Weight in Kilogrammes.
Rāḍhi Brahmin ..	90·24	246·32	95·40	877·04	439·32	380·64	57·655
Muchi	90·01	244·22	96·13	866·65	427·73	383·01	44·294

	Length-Breadth Index of Head.	Length-Height Index of Head.	Breadth-Height Index of Head.	Proportional Head Indices (after F. G. Parsons). Length.	Breadth.	Height.	Transversal Fronto-Parietal Index.	Head Modulus.	Physiognomical Upper Facial Index (Broca).	Morphological Facial Index.
Rāḍhi Brahmin..	82·25	69·99	86·46	0·339	0·323	0·278	68·28	461·02	78·74	83·97
Muchi ..	79·22	65·70	82·94	0·408	0·323	0·269	69·91	437·69	75·32	90·19

	Physiognomic Upper Facial Index.	Morphological Upper Facial Index.	Orbito-Nasal Index.	Jugo-Mandibular Index.	Jugo-Frontal Index.	Transversal Cephalo-Facial Index.	Vertical Cephalo-Facial Index.	Nasal Index.	Elevation Index of Nose.	Physiognomic Ear Index.
Rāḍhi Brahmin	54·93	48·625	117·57	72·93	75·15	90·26	87·90	64·28	60·58	53·98
Muchi ..	54·13	47·430	114·46	72·00	76·99	90·82	97·05	68·98	58·01	57·49

	Indices of Body Proportions.								
	Span-Stature.	Trunk-Stature.	Total Arm-Stature.	Upper Arm-Stature.	Lower Arm-Stature.	Hand Length-Stature.	Total Leg-Stature.	Upper Leg-Stature.	Lower Leg-Stature.
Rāḍhi Brahmin ..	102·35	31·92	43·85	18·96	15·05	11·16	52·85	26·42	20·18
Muchi ..	102·96	30·11	41·63	19·39	15·43	11·28	53·64	26·47	23·70

	Indices of Body Proportions.						
	Foot Length -Stature.	Head Height -Stature.	Shoulder Width -Stature.	Hip-Girth-Stature.	Chest Girth Inspiration -Stature.	Sitting Height -Stature.	Navel Height -Stature.
Rāḍhi Brahmin ..	14·84	13·04	22·11	17·21	52·92	52·32	60·41
Muchi ..	15·11	12·10	21·37	15·74	49·83	49·64	58·81

	Indices of Body Proportions.								
	Total Arm-Trunk.	Upper Arm-Trunk.	Lower Arm-Trunk.	Hand Length-Trunk.	Total Leg-Trunk.	Upper Leg-Trunk.	Lower Leg-Trunk.	Foot Length-Trunk.	Shoulder Width -Trunk.
Rāḍhi Brahmin	139·13	59·63	47·32	35·00	167·53	83·08	71·91	47·05	70·22
Muchi ..	138·27	64·89	51·27	37·48	170·98	87·92	78·73	50·20	70·98

	Indices of Body Proportions.								Height Weight Index of Build.
	Hip Width-Trunk.	Hip Width-Shoulder Width.	Arm Length - Leg Length.	Lower Arm - Upper Arm.	Lower Leg - Upper Leg.	Hand Breadth-Hand Length.	Foot Breadth - Foot Length.	Oral Index.	
Rāḍhi Brahmin ..	**54·30**	**77·32**	**84·13**	**85·74**	**86·64**	**44·15**	**38·71**	**33·63**	**1·22**
Muchi ..	**52·28**	**73·66**	**79·62**	**79·01**	**89·54**	**43·58**	**39·36**	**36·45**	**1·09**

RĀḌHI BRAHMANAS OF BENGAL.

Serial No.	Name.	Age.	Residence.	District of Birth.	Father's District.	Mother's District.	Occupation.	Brothers.	Sisters.	Sons.	Daughters.
1	H. K. Mukherji ..	35	Calcutta	24 Parganas	Hughli	Howrah	Service	5	4	..	..
2	D. D. Chakrabarty ..	33	,,	Barisal	Barisal	Barisal	Service	2	1	..	..
3	T. P. Bhattacharyya	35	,,	Faridpur	Faridpur	Barisal	Service	3	5	..	..
4	A. C. Chakrabarty ..	34	,,	Faridpur	Faridpur	Faridpur	Service	6	4	1	1
5	A. K. Mukherji ..	22	,,	Birbhum	Birbhum	Burdwan	Student	2	..	..	..
6	G. C. Banerjee ..	26	,,	Faridpur	Faridpur	Faridpur	Student	7	2	..	..
7	N. K. Chakravarty ..	37	,,	Faridpur	Faridpur	Faridpur	Service	2	2	1	3
8	S. C. Chakravarty ..	21	,,	Dacca	Dacca	Dacca	Student	2	1	..	..
9	S. R. Devasharma ..	30	,,	Howrah	Faridpur	Dacca	Business	4	1	..	..
10	K. L. Simlai ..	25	,,	Calcutta	Calcutta	24 Parganas	Priest	2	3	..	..
11	T. C. Mukherji ..	33	,,	Calcutta	24 Parganas	Calcutta	Business	1	..	..	..
12	R. C. Ganguli ..	43	,,	Calcutta	Calcutta	Calcutta	Business	3	5	..	..
13	P. C. Ghosal ..	39	,,	Dacca	Dacca	Dacca	Service	1	..	..	..
14	P. D. Mukherji ..	36	,,	Burdwan	24 Parganas	Burdwan	Teacher	2	2	3	1
15	S. N. Chatterji ..	37	,,	Howrah	Howrah	24 Parganas	Service	2	4	..	..
16	S. C. Mukherji ..	37	,,	Calcutta	Midnapur	Midnapur	Business	6	5	..	..
17	S. K. Mukherji ..	27	,,	Calcutta	Midnapur	Midnapur	Service	6	5	..	..
18	S. R. Mukherji ..	21	,,	Calcutta	Calcutta	24 Parganas	Service	1	1	..	..
19	S. N. Chatterji ..	20	,,	Nadiya	Nadiya	Nadiya	Student	4	..	..	..
20	C. L. Mukherji ..	40	,,	Calcutta	Calcutta	24 Parganas	Pleader	3	5	1	..
21	H. D. Mukherji ..	31	,,	Rangpur	24 Parganas	24 Parganas	Business	1	3	..	..
22	N. L. Mukherji ..	29	,,	Calcutta	Khulna	Calcutta	Service	1	..	..	..
23	H. S. Devasharma ..	37	,,	Faridpur	Faridpur	Dacca	Teacher	4	1	1	2
24	N. N. Chatterji ..	40	,,	Nadiya	Nadiya	Nadiya	Doctor	4	4	..	..
25	B. M. Banerji ..	35	,,	Nadiya	Calcutta	Nadiya	Business	3	6	..	..

Serial No.	Circumferences (in mm.): Horizontal Circumference of Head (45).	Longitudinal Arc of Head (48).	Transversal Arc of Head (49).	Maximum Girth of Upper Arm (65).	Girth of Wrist (67).	Girth of Calf (69).	Girth of Ankle (70).	Chest Girth: Inspiration (61a).	Chest Girth: Expiration (61b).	Head Measurements (in mm.): Maximum Head Length (1).	Maximum Head Breadth (3).	Auricular Height of Head (15c).	Total Head Height (16).	Minimum Frontal Breadth (4).	Maximum Bizygomatic Breadth (6).	Bigonial Breadth (8).	Serial No.
1	515	330	335	208	142	293	194	816	764	179	147	126	221	93	136	98	1
2	558	345	354	245	144	318	203	846	815	186	153	141	214	104	136	100	2
3	518	322	332	228	156	320	207	850	823	181	144	127	224	100	135	100	3
4	540	325	337	230	160	293	185	740	730	188	150	126	219	88	139	101	4
5	565	350	335	300	170	373	228	1020	970	185	145	132	210	93	137	106	5
6	513	337	342	220	145	280	175	815	275	176	138	132	219	97	126	100	6
7	540	340	338	200	145	280	188	805	760	185	145	131	224	103	134	103	7
8	538	356	330	245	145	330	205	875	830	185	147	123	197	98	127	98	8
9	540	340	332	230	150	295	190	890	840	182	154	139	218	110	138	102	9
10	520	340	324	260	145	308	184	860	830	177	143	128	198	100	126	92	10
11	550	340	320	250	150	340	205	935	905	189	146	121	223	95	·142	98	11
12	557	362	372	205	138	250	178	797	750	192	155	136	213	105	132	100	12
13	520	310	325	250	150	340	205	900	875	178	145	128	204	99	135	98	13
14	541	350	346	252	160	330	200	950	900	185	146	124	208	102	136	103	14
15	541	355	337	225	160	287	194	800	780	185	153	134	215	104	131	96	15
16	570	350	343	292	170	370	220	1072	1055	188	150	122	218	108	141	101	16
17	540	343	343	290	152	360	235	990	970	182	157	131	220	96	133	98	17
18	528	332	328	295	171	395	225	970	955	177	152	129	222	91	137	100	18
19	539	338	350	225	148	305	190	812	795	185	143	135	230	100	127	103	19
20	540	336	346	240	148	320	185	860	843	178	156	127	226	97	138	100	20
21	557	360	353	230	155	325	200	880	840	189	155	128	220	106	143	102	21
22	566	346	348	280	175	360	222	1010	975	185	158	133	227	110	146	110	22
23	554	340	342	217	145	302	185	864	836	185	148	112	230	104	131	94	23
24	558	344	340	288	175	390	228	1162	1060	190	155	147	244	102	145	115	24
25	536	350	350	218	145	288	183	802	770	190	146	118	242	110	135	95	25

N.B.—The figures within parentheses after the headlines refer to the numbers of measurements of the head and the body respectively in R. Martin's *Lehrbuch der Anthropologie*, second edition, Jena, 1928.

RĀḌHI BRAHMANAS OF BENGAL.

Head Measurements (in mm.).

Serial No.	Physiognomical Total Facial Height (17).	Morphological Total Facial Height (18).	Physiognomical Upper Facial Height (19).	Morphological Upper Facial Height (20).	Nasal Height (21).	Nasal Breadth (13).	Nasal Depth (22).	Interocular Breadth (9).	External Orbital Breadth (10—1).	Bi-orbito Nasal Arc (10—2).	Labial Height (25).	Breadth of Mouth (14).	Physiognomic Length of Ear (29).	Physiognomic Breadth of Ear (30).	Serial No.
1	157	108	68	63	53	38	20	29	110	120	11	40	52	29	1
2	180	123	77	69	57	33	25	34	103	113	17	47	58	33	2
3	175	118	75	63	56	32	22	31	104	115	14	44	64	38	3
4	182	121	76	68	56	37	26	30	112	143	15	54	60	35	4
5	160	110	74	63	52	35	20	30	104	122	18	49	61	27	5
6	154	112	78	65	56	38	20	31	104	130	11	48	66	35	6
7	169	115	68	60	50	35	25	32	111	140	14	47	59	34	7
8	156	106	70	61	51	38	20	29	110	125	15	50	62	38	8
9	188	116	79	58	53	35	19	30	115	132	16	46	60	31	9
10	155	113	76	66	55	40	20	31	109	132	12	51	63	31	10
11	181	116	78	69	51	36	19	29	114	124	16	45	60	33	11
12	176	114	69	65	55	33	18	32	115	128	13	50	57	35	12
13	183	108	70	61	56	32	21	29	112	129	19	48	68	37	13
14	173	101	64	57	54	34	20	30	117	144	11	52	63	33	14
15	175	114	77	68	61	33	24	28	111	128	17	50	57	32	15
16	166	109	70	62	51	39	24	27	118	140	18	52	61	35	16
17	162	97	67	57	43	36	22	27	107	125	16	49	59	32	17
18	181	117	70	66	59	31	21	26	107	135	14	45	66	36	18
19	161	102	65	61	49	37	23	32	106	126	11	49	61	29	19
20	176	117	83	69	60	33	25	29	109	125	12	44	65	36	20
21	182	124	82	72	60	34	30	33	111	132	17	53	62	41	21
22	180	119	78	70	52	38	20	33	119	134	12	41	64	39	22
23	175	118	81	67	59	34	29	33	103	119	16	54	56	30	23
24	184	126	72	71	59	32	26	29	113	135	14	45	65	33	24
25	185	124	90	72	57	36	23	30	102	115	14	46	62	32	25

RĀḌHI BRAHMANAS OF BENGAL.

Body Measurements (in mm.).

Serial No	Stretch of Arms (17).	HEIGHT. Vertex (1).	Tragion (2).	Supraster-nale (4).	Acromion (8).	Radiale (9).	Stylion (10).	Dactylion (11).	Tibiale (15).	Spherion (16).	Omphalion (5).	Iliospinale (13).	Sitting Height Vertex (23).	Serial No.
1	1660	1624	1498	1318	1300	996	756	584	404	51	985	871	351	1
2	1669	1591	1450	1291	1314	991	756	564	430	60	933	869	839	2
3	1641	1631	1504	1352	1322	1029	809	640	425	59	997	940	850	3
4	1795	1704	1578	1381	1399	1061	788	593	456	44	1007	929	889	4
5	1735	1719	1587	1393	1411	1091	834	670	459	76	1047	946	880	5
6	1822	1713	1581	1401	1386	1064	817	609	460	60	1037	924	900	6
7	1735	1651	1520	1340	1340	1027	747	572	436	77	992	916	860	7
8	1599	1542	1419	1255	1266	992	758	575	411	57	992	850	815	8
9	1695	1667	1528	1360	1339	1031	800	587	433	73	995	892	877	9
10	1687	1632	1504	1330	1320	1006	788	560	428	72	982	905	846	10
11	1759	1702	1580	1392	1403	1088	820	619	453	62	1043	923	854	11
12	1661	1672	1536	1348	1332	1027	778	585	442	42	978	881	869	12
13	1720	1610	1482	1326	1334	1022	774	526	439	73	970	929	827	13
14	1634	1641	1517	1354	1329	1029	799	627	463	59	976	909	880	14
15	1682	1668	1534	1371	1369	1044	781	605	441	75	985	879	902	15
16	1642	1656	1534	1377	1356	1086	808	635	418	65	959	892	916	16
17	1570	1610	1479	1305	1320	1037	815	619	415	65	952	854	866	17
18	1767	1666	1537	1346	1337	1019	771	580	439	64	963	892	885	18
19	1803	1758	1623	1436	1444	1106	820	637	473	65	1080	992	904	19
20	1707	1669	1542	1351	1369	1040	796	526	442	55	1019	935	845	20
21	1806	1723	1595	1410	1382	1055	805	624	455	63	1046	923	903	21
22	1714	1699	1566	1400	1382	1075	823	621	450	61	1019	942	868	22
23	1574	1564	1452	1258	1271	961	744	603	403	68	946	842	848	23
24	1802	1753	1606	1442	1424	1115	785	592	458	57	1018	951	926	24
25	1681	1645	1527	1326	1340	1026	789	603	440	67	988	902	860	25

RĀḌHI BRAHMANAS OF BENGAL

Serial No.	Body Measurements (in mm).														Weight in Kilogramme (71).	Normal Weight (kg.) (corresponding to stature).	Serial No.
	Trunk Length (27).	Shoulder Width (35).	Maximum Hip Width (40).	Total Arm Length (45).	Upper Arm Length (47).	Lower Arm Length (48).	Hand Length (49).	Hand Breadth (52).	Middle Finger Length (51).	Foot Length (58).	Foot Breadth (59).	Total Leg Length (53).	Upper Leg Length (55).	Lower Leg Length (56).			
1	536	364	260	720	308	241	179	78	85	240	91	841	434	353	44·452	62·4	1
2	506	370	260	714	290	254	192	80	93	243	109	839	408	370	47·173	59·1	2
3	493	358	285	698	309	236	183	78	89	249	100	911	480	366	58·513	63·1	3
4	542	376	277	778	353	269	199	80	93	249	92	889	440	412	53·070	65·4	4
5	537	415	312	738	312	270	185	82	92	242	91	906	453	383	78·017	66·9	5
6	572	380	271	770	305	282	208	78	95	272	91	894	431	400	47·173	66·3	6
7	509	390	270	747	296	273	190	80	90	238	98	886	446	359	44·452	60·1	7
8	486	340	253	667	278	225	175	81	85	239	98	820	408	354	53·524	54·2	8
9	562	385	265	717	305	245	193	79	94	246	91	852	426	360	50·802	61·7	9
10	510	388	270	716	316	240	190	79	89	245	100	875	444	356	53·524	63·2	10
11	563	372	309	753	334	273	192	82	94	258	112	883	437	391	67·131	65·1	11
12	560	375	266	737	312	238	188	80	92	250	94	841	408	400	38·101	62·2	12
13	476	359	305	745	328	253	189	80	91	244	100	889	456	366	62·595	61·0	13
14	534	376	296	716	302	227	189	78	89	240	93	879	415	404	63·503	64·1	14
15	590	371	258	744	318	257	187	83	86	235	100	839	407	366	46·266	61·8	15
16	582	379	333	702	303	238	190	83	88	241	94	862	441	353	78·925	60·6	16
17	541	366	313	679	293	226	184	83	88	250	90	824	408	350	66·224	61·0	17
18	546	400	305	775	329	278	194	87	90	252	107	852	421	375	70·760	61·6	18
19	533	359	275	788	330	279	194	83	93	262	95	952	483	408	50·802	65·8	19
20	599	348	302	734	331	257	191	79	92	259	99	895	458	387	61·688	61·9	20
21	584	381	287	770	355	244	190	82	92	257	101	883	435	392	58·059	67·3	21
22	550	359	296	725	316	250	186	81	87	250	105	902	458	389	72·574	64·9	22
23	499	346	275	672	290	227	172	73	81	225	86	812	408	335	51·709	56·4	23
24	589	411	339	763	326	265	202	87	100	263	106	911	458	401	89·811	65·3	24
25	509	370	277	713	316	255	194	82	81	252	95	872	430	373	49·441	64·5	25

RĀḌHI BRAHMANAS OF BENGAL.

Indices of the Head.

Serial No.	Length-Breadth Index of Head.	Length-Height Index of Head.	Breadth-Height Index of Head.	Transversal Fronto-parietal Index.	Head Modulus.	Physiognomical Facial Index (Broca).	Morphological Facial Index.	Physiognomical Upper Facial Index.	Morphological Upper Facial Index.	Orbito-Nasal Index.	Jugo-Mandibular Index.	Jugo-Frontal Index.	Transversal Cephalo-Facial Index.	Vertical Cephalo-Facial Index.	Nasal Index.	Elevations Index of Nose.	Physiognomic Ear Index.	Proportional Head Indices (after F. G. Parsons). Length.	Breadth.	Height.
1	82·12	70·39	85·71	63·27	452	86·62	79·41	50·00	46·32	109·09	72·06	68·38	92·52	85·71	71·70	52·63	55·77	0·396	0·325	0·279
2	82·26	75·81	92·16	67·97	480	75·56	90·44	56·62	50·73	109·71	73·53	76·47	88·89	87·23	57·89	75·76	56·90	0·387	0·319	0·294
3	79·56	81·22	88·19	69·44	452	77·14	84·41	55·56	46·67	110·58	74·07	74·07	93·75	92·91	57·14	68·75	59·38	0·400	0·319	0·281
4	79·79	67·02	84·00	58·67	464	76·37	87·05	54·70	48·92	127·67	72·66	63·31	92·67	85·71	66·07	70·27	58·33	0·405	0·323	0·272
5	78·38	71·35	91·03	64·14	462	85·63	80·29	54·01	45·98	117·31	77·37	67·88	94·48	90·15	67·31	57·14	44·26	0·400	0·314	0·286
6	78·41	75·00	95·65	70·29	446	81·82	88·89	61·90	51·59	125·00	79·37	76·98	91·30	89·39	67·86	52·63	53·03	0·395	0·309	0·296
7	78·34	70·81	90·34	71·03	461	79·29	85·82	50·75	44·78	126·13	76·87	76·87	92·41	90·08	70·00	71·43	57·63	0·401	0·315	0·284
8	79·46	66·49	83·67	66·67	455	81·41	83·46	55·12	48·03	113·64	77·17	77·17	86·39	93·50	74·51	52·63	61·29	0·407	0·323	0·270
9	84·62	76·37	90·26	71·43	475	73·80	84·06	57·20	42·03	114·78	73·91	79·71	89·61	81·29	66·04	54·29	51·67	0·383	0·324	0·293
10	80·79	72·32	89·51	69·93	448	81·29	89·68	60·32	52·38	121·00	73·02	79·37	88·11	84·38	72·73	50·00	49·21	0·395	0·319	0·286
11	77·25	64·02	82·88	65·07	456	78·45	81·69	54·93	48·59	108·77	69·01	66·90	97·26	93·39	70·59	52·78	55·00	0·415	0·320	0·265
12	80·73	70·83	87·78	67·74	483	75·00	86·36	52·27	49·62	111·30	75·76	79·55	85·16	82·35	60·00	54·55	61·40	0·397	0·321	0·282
13	81·46	71·91	88·28	68·28	451	73·77	80·00	51·85	45·19	115·18	72·59	73·33	93·10	86·72	57·14	65·63	54·41	0·395	0·321	0·284
14	78·92	67·03	84·93	69·86	455	78·61	74·26	47·06	41·91	123·10	75·74	75·00	93·15	88·71	62·96	58·82	52·38	0·406	0·321	0·273
15	82·70	72·43	87·58	67·97	472	74·86	87·02	58·78	51·91	115·32	73·28	79·39	85·62	85·07	54·10	72·73	56·14	0·392	0·324	0·284
16	79·79	64·89	81·33	72·00	460	84·94	77·30	49·60	43·97	118·64	71·63	76·60	94·00	85·25	76·47	61·54	57·38	0·409	0·326	0·265
17	86·26	71·98	83·44	61·15	470	82·10	72·93	50·38	42·86	116·82	73·68	72·18	84·71	83·21	83·72	61·11	54·24	0·387	0·334	0·279
18	85·88	72·88	84·87	59·87	458	75·69	85·40	51·10	48·17	126·17	72·99	66·42	90·13	93·02	52·54	67·74	54·55	0·386	0·332	0·282
19	77·30	72·97	94·41	69·93	463	78·88	80·31	51·18	48·03	118·17	81·10	78·74	88·81	77·04	75·51	62·16	47·54	0·399	0·309	0·292
20	87·64	71·35	81·41	62·18	461	78·41	84·78	60·14	50·00	114·68	72·46	70·29	88·46	74·80	55·00	75·76	55·38	0·386	0·338	0·276
21	82·01	67·72	82·58	68·39	472	78·57	86·71	57·34	50·35	118·92	71·33	74·13	92·26	87·50	56·67	88·24	66·13	0·401	0·328	0·271
22	85·41	71·89	84·18	69·62	476	81·11	81·51	53·40	47·94	112·61	75·34	75·34	92·41	85·71	73·08	52·63	60·94	0·389	0·332	0·279
23	80·00	60·54	75·68	70·27	445	74·86	90·08	61·83	51·15	115·53	71·76	79·39	87·92	105·36	57·63	85·29	53·57	0·416	0·332	0·252
24	81·58	77·37	94·84	65·81	492	78·80	86·90	44·65	48·96	119·47	79·31	70·34	93·55	85·71	54·24	81·25	50·77	0·386	0·315	0·299
25	76·84	62·11	80·27	75·34	454	72·97	91·85	66·67	53·33	112·75	70·37	85·93	91·84	105·08	63·16	63·89	51·61	0·418	0·322	0·260

RĀḌHI BRAHMANAS OF BENGAL.

Indices of Body Proportions.

Serial No.	Span-Stature.	Trunk-Stature.	Total Arm-Stature.	Upper Arm-Stature.	Lower Arm-Stature.	Hand Length-Stature.	Total Leg-Stature.	Upper Leg-Stature.	Lower Leg-Stature.	Foot Length-Stature.	Head-Height-Stature.	Shoulder-Width-Stature.	Hip Girth-Stature.	Chest Girth (Inspiration)-Stature.	Sitting Height-Stature.	Serial No.
1	102·47	33·33	44·44	18·51	14·81	11·11	51·85	26·54	21·60	14·81	13·58	22·22	16·05	50·62	52·47	1
2	105·03	32·07	32·07	18·24	15·09	12·34	54·55	26·62	24·02	15·58	13·64	24·02	16·88	55·90	54·55	2
3	100·61	30·06	30·06	19·02	14·72	11·04	55·83	29·44	22·70	15·34	14·11	22·08	17·18	52·15	52·15	3
4	105·29	31·76	45·88	20·58	15·88	11·76	52·35	25·88	24·12	14·70	12·94	22·35	16·47	43·53	52·35	4
5	101·17	31·39	43·02	18·02	15·69	10·46	52·91	26·16	22·09	13·95	12·21	23·84	18·02	59·30	51·16	5
6	106·43	33·33	45·02	17·54	16·37	12·28	52·05	25·14	23·39	15·78	12·86	22·22	15·79	47·37	52·63	6
7	104 85	30·91	45·45	18·18	16·36	11·51	53·70	27·27	21·82	14·54	13·33	23·64	16·36	48·48	52·12	7
8	103·90	31·81	43·51	18·18	14·28	11·38	53·25	26·62	22·73	13·95	12·99	22·08	16·23	56·49	52·60	8
9	101·20	33·53	43·11	17·96	14·37	11·37	50·90	25·75	21·56	15·78	13·17	22·75	15·57	53·29	52·69	9
10	103·68	31·28	44·17	19·75	14·72	11·65	53·37	26·99	22·08	14·54	12·27	23·93	16·56	52·76	52·15	10
11	103·53	32·94	44·11	19·41	15·88	11·17	51·76	25·88	22·94	15·58	12·94	21·76	18·23	54·70	50·00	11
12	99·40	33·53	44·31	18·56	14·37	11·37	50·30	24·70	23·95	14·97	12·57	22·15	16·17	47·30	52·10	12
13	106·83	29·81	45·96	19·30	15·52	11·80	55·28	28·57	22·98	14·90	12·42	22·36	18·63	55·90	51·55	13
14	99·39	32·07	43·90	18·29	14·02	11·58	53·66	25·00	24·40	14·63	12·80	23·17	18·29	51·83	53·66	14
15	100·60	35·32	44·31	19·16	15·57	11·37	50·30	24·51	22·16	13·77	12·57	22·15	15·57	47·90	53·89	15
16	98·80	34·93	42·16	18·07	14·46	11·44	51·81	26·51	21·08	14·46	13·25	22·89	19·88	64·58	55·42	16
17	97·52	33·54	42·23	18·01	14·28	11·18	50·93	25·46	21·74	15·52	13·66	22·98	19·25	61·49	54·04	17
18	105·99	32·33	46·10	19·76	16·76	11·37	50·90	25·15	22·16	14·97	13·17	23·95	17·96	58·03	52·69	18
19	102·27	30·11	44·88	18·75	15·91	10·73	53·98	27·27	23·29	14·77	13·07	20·45	15·34	46·02	51·10	19
20	102·40	29·94	43·71	19·76	15·57	11·37	53·29	27·54	23·35	15·57	13·77	20·96	17·96	51·50	50·30	20
21	105·23	33·72	44·76	20·35	13·95	11·04	51·16	25·00	22·67	15·12	12·79	22·09	16·86	51·16	52·33	21
22	100·59	32·35	42·35	18·82	14·70	11·17	52·94	27·06	22·94	14·70	13·53	21·18	17·65	59·41	51·18	22
23	100·64	32·05	42·95	18·59	14·74	10·90	51·92	26·28	21·15	14·10	14·74	22·43	17·31	55·13	54·49	23
24	100·86	33·52	43·43	18·86	14·86	11·42	57·74	26·28	22·86	14·86	13·71	23·43	19·43	66·40	53·14	24
25	102·44	31·10	43·29	19·51	15·24	11·58	53·05	26·22	22·56	15·24	14·63	22·56	17·07	48·78	52·44	25

RADHI BRAHMANAS OF BENGAL.

Indices of Body Proportions.

Serial No.	Total Arm-Trunk.	Upper Arm-Trunk.	Lower Arm-Trunk.	Hand Length-Trunk.	Total Leg-Trunk.	Upper Leg-Trunk.	Lower Leg-Trunk.	Foot Length-Trunk.	Shoulder Width-Trunk.	Hip Width-Trunk.	Hip Width-Shoulder Width.	Arm Length-Leg Length.	Lower Arm-Upper Arm.	Lower Leg-Upper Leg.	Hand Breadth-Hand Length.	Foot Breadth-Foot Length.	Height-Weight Index of Build.	Serial No.
1	133·33	57·41	44·44	33·33	156·90	78·18	64·81	44·44	66·67	48·15	72·22	85·71	77·42	81·40	43·57	47·92	1·04	1
2	139·22	56·86	49·02	37·25	165·81	78·85	72·55	47·06	62·55	50·98	70·27	84·52	86·21	90·24	41·67	44·85	1·29	2
3	141·58	64·58	48·98	36·73	184·79	97·96	75·51	51·02	73·47	57·14	77·78	76·92	77·42	77·08	42·62	40·16	1·35	3
4	143·54	64·81	50·00	37·04	164·02	81·48	75·93	46·30	70·37	51·85	73·68	87·64	77·14	93·18	40·20	36·00	1·08	4
5	137·04	57·41	50·00	33·33	168·71	83·33	70·37	44·44	75·93	57·41	75·61	81·32	87·10	84·44	44·32	37·50	1·53	5
6	135·09	52·63	49·12	35·84	156·29	75·44	70·18	47·37	66·67	47·37	71·05	86·52	93·33	93·02	37·02	33·33	0·94	6
7	146·76	58·82	52·94	37·25	174·07	88·24	70·59	47·06	76·47	52·94	69·23	84·27	90·00	80·00	42·11	41·67	0·99	7
8	136·73	57·14	44·90	34·69	168·72	83·67	71·43	48·98	69·39	51·02	73·53	81·71	78·57	85·37	46·29	41·67	1·46	8
9	128·57	53·57	42·86	33·93	151·60	76·79	64·29	44·64	67·86	46·43	68·42	84·71	80·00	83·72	40·93	44·00	1·09	9
10	141·18	62·75	47·06	37·25	171·56	86·27	70·59	47·06	76·47	52·94	69·23	86·21	75·00	81·82	41·56	41·67	1·23	10
11	133·93	58·93	48·21	33·93	156·84	78·57	69·64	46·43	66·07	55·36	83·78	85·23	81·82	88·64	42·71	42·31	1·37	11
12	132·14	55·36	42·86	33·93	150·18	73·21	71·43	44·64	66·07	48·21	72·97	88·10	77·42	97·56	42·55	36·00	0·82	12
13	154·17	68·75	52·08	39·58	186·76	95·83	77·08	50·00	75·00	62·50	83·33	83·15	75·76	80·43	44·35	41·67	1·50	13
14	135·85	56·60	43·40	35·85	164·62	77·36	75·47	45·28	71·70	56·60	78·95	81·82	76·67	97·56	41·27	37·50	1·44	14
15	125·42	54·24	44·07	32·20	142·20	69·49	62·71	38·98	62·71	44·07	70·27	88·10	81·25	90·24	44·39	43·48	0·99	15
16	120·69	51·72	41·38	32·76	148·11	75·86	60·34	41·38	65·52	56·90	86·84	81·40	80·00	79·55	43·68	37·50	1·72	16
17	125·93	53·70	42·59	33·33	152·31	75·93	64·81	46·30	68·52	57·41	83·78	82·93	79·31	85·37	45·11	36·00	1·59	17
18	142·20	61·11	51·85	35·19	156·33	77·78	68·52	46·30	74·01	55·56	75·00	90·59	84·85	88·10	44·85	44·00	1·52	18
19	147·84	62·26	52·83	35·85	178·61	90·57	77·36	49·06	67·92	50·94	75·00	83·16	84·85	85·42	42·78	34·62	0·93	19
20	146·00	66·00	52·00	38·00	179·36	92·00	78·00	52·00	70·00	60·00	85·71	82·02	78·79	84·78	41·36	38·46	1·21	20
21	132·76	60·34	41·38	32·76	151·20	74·14	67·24	44·83	65·52	50·00	76·32	87·50	68·57	90·70	43·16	38·46	1·14	21
22	130·91	58·18	45·45	34·55	164·00	81·82	70·91	45·45	65·45	54·55	83·33	80·00	78·13	84·78	43·55	40·00	1·48	22
23	134·00	58·00	46·00	34·00	162·72	82·00	67·00	45·00	70·00	54·00	77·14	82·72	78·13	80·49	42·44	40·91	1·36	23
24	128·31	55·93	44·07	33·90	154·67	77·97	67·80	44·07	69·49	57·63	82·93	83·52	78·79	85·96	43·07	42·31	1·67	24
25	139·22	62·75	49·02	37·25	171·32	84·31	72·55	49·02	72·55	54·90	73·68	81·61	78·13	86·05	42·27	36·00	1·12	25

RĀḌHI BRAHMAṆAS OF BENGAL.

Observations.

Serial No.	Skin Colour. Inner side of Arm.	Skin Colour. Cheek.	Hair. Character. Form.	Hair. Character. Texture.	Hair. Character. Colour.	Hair. Quantity. Head.	Hair. Quantity. Lip and Chin.	Hair. Quantity. Body.	Ear. Lobe.	Ear. Darwinian Tubercle.	Eye. Colour.	Eye. Form.	Eye. Epicanthic Fold.	Eye brows. Form.	Eye brows. Thickness.	Eye brows. Supra-orbital Ridges.	Serial No.
1	17	18	St.	M	X	+	+	++	At.	*Nil*	2	St.	*Nil*	Sep.	++	+	1
2	27	27	LW	M	X	++	++	+	,,	R	2	,,	,,	,,	++	+	2
3	17	15	DW	M	Y	++	+	+	Sep.	*Nil*	2	,,	,,	,,	+	+	3
4	19	20	St.	M	,,	++	++	++	,,	,,	3	,,	,,	,,	++	+	4
5	14	14	DW	F	,,	++	+	++	At.	L	3	,,	,,	,,	++	+	5
6	16	16	LW	M	,,	++	+	++	Sep.	RL	2	,,	,,	,,	++	+	6
7	12	13	DW	,,	,,	++	+	++	At.	*Nil*	3	,,	,,	,,	++	+	7
8	19	20	LW	,,	,,	++	++	+	Sep.	,,	4	,,	,,	Con.	++	+	8
9	14	17	,,	,,	,,	+	+	++	,,	L	4	,,	,,	Sep.	++	+	9
10	12	13	St.	,,	,,	++	+	++	,,	*Nil*	4	,,	,,	,,	+++	+	10
11	16	17	,,	,,	,,	++	++	++	,,	,,	3	,,	,,	,,	++	+	11
12	14	15	LW	,,	,,	++	++	+	At.	RL	4	,,	,,	,,	++	+	12
13	16	17	,,	,,	,,	+	+	+	Sep.	,,	4	,,	,,	,,	++	+	13
14	14	15	,,	,,	X	++	++	++	At.	,,	3	,,	,,	,,	+++	+	14
15	17	18	,,	,,	Y	++	++	++	Sep.	*Nil*	3	,,	,,	,,	++	+	15
16	12	15	Curly	,,	X	+	++	++	,,	,,	5	,,	,,	,,	++	+	16
17	15	15	LW	,,	Y	++	++	+	At.	,,	2	,,	,,	,,	++	+	17
18	10	11	DW	,,	X	+++	++	+	Sep.	R	2	,,	,,	,,	++	+	18
19	13	13	St.	,,	Y	++	+	++	At.	*Nil*	2	,,	,,	,,	+	+	19
20	7	9	LW	,,	,,	++	++	++	,,	,,	4	,,	,,	Con.	+++	+	20
21	12	14	,,	,,	,,	++	+	+	Sep.	RL	4	,,	,,	Sep.	++	+	21
22	15	17	DW	,,	,,	+++	++	++	,,	,,	3	,,	,,	,,	++	+	22
23	16	17	St.	,,	,,	++	+	+	,,	*Nil*	4	,,	,,	,,	+++	+	23
24	7	9	,,	F	X	+	++	++	,,	,,	4	,,	,,	,,	+	+	24
25	12	13	,,	,,	Y	—	+	++	At.	L	2	,,	,,	,,	++	+	25
	The numbers refer to F. von Luschan's Hautfarbentafel.		St.=Straight. LW=Low waves. DW=Deep waves.	C=coarse. M=medium. F=fine.	The letters refer to the new Haarfarbentafel of E. Fischer.	+=scanty. ++=medium. +++=thick.			At.=attached. Sep.=separate.	R=right ear. L=left ear. RL=both ears.	The numbers refer to R. Martin's Augenfarbentafel.	St.=straight. O=oblique.		Con=connected. Sep.=separate.	+=thin. ++=medium. +++=thick.	+=trace. ++=moderate. +++=pronounced.	

RĀḌHI BRAHMANAS OF BENGAL.

Serial No.	Nose.			Forehead.		Malars Prominence.	Lips.		Teeth Incisor Fold.	Chin.		Face.			Body-Musculature.	Hand-pressure (in kg.)		Serial No.
	Depression (Root).	Bridge.	Septum.	Height.	Breadth.		Thickness.	Eversion.		Character.	Form.	Form.	Prognathism.	Angles of Lower Jaw.		Right.	Left.	
1	+	Cv.	D	M	M	+	++	*Nil*	*Nil*	M	O	O	*Nil*	+	W	34	30	1
2	+	,,	,,	,,	,,	+	++	,,	,,	,,	,,	,,	,,	+	,,	33	30	2
3	+	,,	,,	,,	,,	+	+	,,	,,	,,	,,	,,	,,	+	,,	32	24	3
4	+	,,	,,	,,	,,	+	+	,,	,,	Pr.	,,	,,	,,	+	,,	23	25	4
5	+	St.	,,	,,	,,	+	+	,,	,,	M	R	,,	,,	+	M	39	34	5
6	+	Cv.	,,	,,	,,	+	+	,,	,,	,,	,,	,,	,,	++	W	30	34	6
7	+	St.	,,	,,	,,	+	+	,,	,,	,,	,,	,,	,,	++	,,	25	17	7
8	+	,,	,,	,,	N	+	+	,,	,,	,,	,,	R	,,	+	M	20	20	8
9	+	Cv.	,,	,,	M	+	+	,,	,,	,,	,,	Rec.	,,	++	,,	30	25	9
10	+	St.	,,	,,	N	+	+	,,	,,	,,	,,	O	,,	+	,,	32	19	10
11	+	,,	,,	,,	M	+	+	,,	,,	Pr.	,,	,,	,,	+	,,	30	25	11
12	+	Cv.	,,	,,	,,	+	+	,,	,,	,,	,,	,,	,,	+	W	27	17	12
13	+	,,	,,	,,	B	+	++	,,	,,	M	,,	R	,,	+	M	24	30	13
14	+	St.	,,	H	,,	+	+	,,	,,	,,	,,	Rec.	,,	+	,,	26	21	14
15	+	Cv.	,,	,,	,,	+	++	,,	,,	Pr.	O	O	,,	+	W	27	25	15
16	+	St.	,,	M	M	+	++	,,	,,	M	R	R	,,	+	Mk.	29	30	16
17	+	,,	,,	,,	,,	+	+	,,	,,	Pr.	,,	,,	,,	+	,,	37	31	17
18	++	Cv.	,,	H	B	+	+	,,	,,	,,	O	O	,,	+	M	28	34	18
19	+	St.	,,	M	M	+	+	,,	,,	M	,,	,,	,,	+	W	32	29	19
20	+	Cv.	,,	,,	,,	+	+	,,	,,	Pr.	,,	,,	,,	+	M	20	15	20
21	++	,,	,,	H	,,	+	++	,,	,,	M	R	Rec.	,,	++	W	35	30	21
22	++	St.	,,	M	,,	+	+	,,	,,	,,	,,	R	,,	+	M	38	25	22
23	+	Cv.	,,	,,	,,	+	+	,,	,,	Pr.	O	O	,,	+	M	17	17	23
24	++	,,	,,	,,	B	+	+	,,	,,	M	R	El.	,,	+	,,	35	33	24
25	++	St.	,,	,,	M	+	+	,,	,,	,,	,,	O	,,	+	W	28	28	25
	+ = Shallow. ++ = Medium. +++ = Deep.	Cv. = Convex. St. = Straight. C = Concave. CC = Concavo-convex.	St. = Straight. D = Downward. U = Upwards.	H = High. M = Medium. L = Low.	N = Narrow. M = Medium. B = Broad.	+ = Slight. ++ = Medium. +++ = Pronounced.	+ = Thin. ++ = Medium. +++ = Thick.			Pr. = Prominent. M = Medium. R = Receding.	O = Oval. R = Round.	O = Oval. R = Round. Rec. = Rectangular. El. = Elliptical.		+ = Submedium. ++ = Medium. +++ = Prominent.	W = Weak. M = Medium. Mk. = Marked.	Measurements were taken with the Dynamometer.		

Section of Anthropology.

Abstracts.

GENERAL.

1. The racial history of South India.

L. K. ANANTHAKRISHNA IYER, Palghat.

An illustrated lecture delivered by the author.

2. The primitive tribes of India and the coming constitution.

T. C. DAS, Calcutta.

The paper discusses the position of the Indian primitive tribes under the new constitution from socio-economic standpoints. The condition of the tribes living in 'protected areas' has been compared with that of the dwellers of '*open areas*' where they have to compete with more advanced peoples of the plains. The various missionary attempts to *civilize* the *savage* have been evaluated.

3. The brachycephalic statuettes from Mohenjodaro, Sumer and early Chaldeo-Sumerian sites and their significance.

P. MITRA, Calcutta.

The brachycephalic type as the ruling and civilizing element in the Sumer and Indus valley culture zones and their possible contribution to the cattle-cereals-wheels-plough culture-complex in the painted pottery cultures of chalcolithic times.

4. The racial element in Vedic religion and philosophy.

H. C. RAY, Calcutta.

ANTHROPOLOGICAL METHOD.

5. Studies with the photographic profiloscope.

P. C. MAHALANOBIS, Calcutta.

Certain improvements have been recently made in the instrument described in a note some time ago, by introducing a locking arrangement for the ear-plugs which makes it possible to fix the position of the head of the subject very accurately. The reliability of measurements also has been investigated with the improved type of apparatus. Three subjects with widely differing profiles were selected for this purpose. Three photographs were taken of each subject on three different days by each of three observers ; in this way nine separate photographs were obtained for each subject. Measurements were then taken of 6 radial lengths on each photograph ; so that 162 different measurements were obtained. The present note gives a detailed analysis of the data with full investigation of residual errors, personal differences in making measurements, the influence of the subject, inter-actions between subject, observer, and character, etc. on the reliability of the measurements by the method

of analysis of variance. It was found that the average value of the coefficient of variation was of the order of one per cent. In other words, when two independent photographs are taken of the same subject, two independent measurements of any particular radial length are likely to differ by not more than one per cent. This, however, is for a single subject. But in anthropometry it is usual to work with averages based on 20 or more subjects. The inaccuracy due to instrumental errors is therefore unlikely to amount to more than one-fourth of one per cent. for samples of size 20, or more than one-tenth of one per cent. for samples of about 100. The accuracy reached in the improved apparatus may therefore be considered satisfactory.

6. A note on the use of indices in anthropometric work.

P. C. Mahalanobis, Calcutta.

In anthropometric work it is usual to use a large number of indices of which the cephalic or nasal indices are typical examples. In calculating the C^2 or the D^2-statistics it is usual to treat such indices as separate characters. This procedure appears, however, to be open to objections from a statistical point of view. If two characters, say, the head length and the head breadth, are statistically independent, the cephalic index will not add anything to the information given by the two characters; on the other hand, if the head length and head breadth are correlated, the value of the coefficient of correlation will furnish all available information. The use of indices is therefore superfluous, provided the correlations are fully utilized. In case the correlations are not included, ratios will supply some information, but in a most inefficient form. A statistical population is fully specified by a certain cluster or density distribution in a P-dimensional space defined by the P-characters. The location of such clusters is completely determined by the magnitude or mean value of the P-characters, while complete information regarding shape is given by the orientation and size of the clusters. Provided all possible correlations between the P-characters are included in the analysis, no further information can be obtained by using indices or any other set of mathematically derived functions. The point to be emphasized in this connection is the fact that with P-characters P-dimensions are both necessary and sufficient for a complete specification of a population, and no mathematical device can in any way increase the available information. It is of course immaterial whether the original P-characters are used for defining the different P-dimensions or indices or other functions of the original variates are selected for this purpose.

SOMATOLOGY.

7. The Dakshinatya Vaidik Brahmanas of Bengal.

T. C. Ray Chaudhuri, Calcutta.

Ten somatological measurements, such as stature, head length, head breadth, head height, nasal height, nasal width, orbito-nasal diameter, orbito-nasal arc, etc. were taken on one hundred individuals, and five indices were calculated from them. Besides, observations were recorded of their skin colour, colour and direction of the eyes, hair texture, and shape of the nose. The biometrical analysis of these measurements has been worked out, and a coefficient of racial likeness has been calculated between the two sections of Vaidik Brahmanas in Bengal, the Dakshinatya and the Paschatya. A somatological comparison has also been made with other classes of Bengal Brahmanas, as well as with Brahmanas of other parts of India.

The Dakshinatya Vaidik Brahmins appear to form a homogeneous series with distinct characters differentiating them from other classes of Brahmins in India.

8. The Brahmanas of Bengal.

T. C. Ray Chaudhuri, Calcutta.

On the basis of somatometric measurements taken by the author on 560 Brahmins of Bengal (Radhiya 167, Varendra 179, Paschatya Vaidik 114, and Dakshinatya Vaidik 100), a comparison has been made, with biometric calculations, between them and other classes of Indian Brahmins—Nagar, Audich, Chitpavan, Deshastha, Karada, Saraswat, Gaud, Tamil, Telegu, Kanarese, Malve, as also the Brahmins of Orissa and the United Provinces.

9. An anthropometric study of the Marwadis.

R. N. Bose, Calcutta.

The paper discusses the measurements taken by the author on one hundred individuals of the Marwadis now living in Calcutta. Twenty-five measurements were taken on each individual according to the methods recommended in Martin's Lehrbuch der Anthropologie, viz. max. head length, max. head breadth, least frontal breadth, bizygomatic breadth, bigonial breadth, nasal height, nasal width, morphological facial height, left hand length, left hand breadth, hor. circumference of head, girth of thorax, height vertex, height tragion, height acromion, height radiale, height stylion, height dactylion, height iliospinale, height tibiale, height spherion, sitting height vertex, sitting height iliocristale, arm stretch, and bi-acromial diameter. Many indices have been calculated and a biometrical analysis of the measurements has been worked out.

10. A note on the presence of light-coloured eyes amongst the population of north-eastern India.

Bhupendranath Datta, Calcutta.

This paper records observations on the light eye colour of eleven subjects from Bengal and Assam. They have been numbered and classified according to Martin's Augenfarbentafel. The subjects are of both sexes, and come from conservative and endogamous Hindu castes, viz. the Kalita, Katni, Nat, Rajbansi, Vaidya, Brahmana, and Tanti, and hence foreign influence can hardly be suspected in any of them. Of these subjects, seven have eye-colours ranging between numbers 7 and 8 of Martin, i.e. green, two have dark grey eyes (Nos. 9-10), one has No. 11 and one, No. 13. Thus ten of them have eyes with mixed colours, and one is blond.

In the Ethnographical Report of the Census of India, 1931, Dr. B. S. Guha gives the lightest eye-colour of Bengal people as ranging between 6 and 7, but certain lighter shades are recorded here.

11. Racial analysis of the Koms of Manipur.

P. C. Das Gupta *and* M. N. Bose, Calcutta.

A statistical analysis of anthropometric measurements taken on fifty male subjects shows that there are three main racial elements among the Koms living in the Manipur State, viz. the Dravidian, the Nesiot and the Pre-Dravidian. The Dravidian element forms the main bulk of the tribe, viz. 44 per cent. The Nesiot element also forms a considerable percentage and the Pre-Dravidian comes up to 6 per cent. The Nesiot

element is highly mixed up and betrays some unmistakable Mongolic features, but the true Mongolic element is very slight.

12. An anthropometric study of the Bunas of Bengal.

M. N. Bose, Calcutta.

The paper records the results of anthropometric measurements taken on 220 adult subjects, including 200 males and 20 females, of the Bunas, an aboriginal people living in Bengal. The measurements have been biometrically analyzed, and the coefficient of racial likeness has been worked out between them and the Santals, the Oraons, and the Mundas.

ETHNIC PSYCHOLOGY.

13. The possibility of a racial significance in colour-preference.

P. C. Das Gupta *and* M. N. Bose, Calcutta.

Observations were taken on one hundred Bengali adult male students, and the results were compared with similar observations made on a primitive tribe of Manipur.

14. Determination of the amount of error in the localization of touch-spot among the Santals.

R. K. Mondol *and* M. N. Bose, Calcutta.

Experiments were made on 50 adult male Santals, and their average error has been graphically determined.

ANTHROPO-BIOLOGY.

15. Vital capacity study amongst the Bengalees.

A. Chatterji *and* A. Sen, Calcutta.

190 Bengalee students were examined. Vital capacity with chest volume and body surface of previous data compared. Correlations made with the data of American students.

16. Early Hindu constitutional types.

P. Mitra, Calcutta.

CRANIOLOGY.

17. Harmonic growth and development in the skull of men and primates.

P. Mitra *and* S. Sircar, Calcutta.

18. Some skulls from Ranchi megaliths.

P. Mitra *and* S. Bose, Calcutta.

Three skulls from megalithic sites near Ranchi. Their affinities with the Adittannallur skull types. Their associated remains—some potteries and iron age artefacts. Megaliths studied.

EVOLUTION AND HEREDITY.

19. Some psycho-biological factors in the doctrine of evolution.

P. MITRA *and* S. SIRCAR, Calcutta.

CULTURAL ANTHROPOLOGY.

20. An ethnological study of the depressed classes of the west coast of southern India. Their present condition. Efforts for improvement of their condition.

L. K. ANANTHAKRISHNA IYER, Palghat.

21. The economic adjustments of a Kuki tribe.

T. C. DAS, Calcutta.

The Chirus of Manipur, in Assam, practise shifting cultivation. The fields at the feet of the hills have attracted them, in recent times, towards the broad valley of the Imphal river, and they have taken to wet cultivation. An attempt has been made, in this paper, to show how this new method of cultivation has affected their social, religious, economic, and political life, and how they are adjusting themselves to their new surroundings.

22. Devadasis in northern and eastern India.

J. C. GHOSH, Calcutta.

Some instances cited from Sanskrit literature and inscriptions about the existence of the custom in Northern and Eastern India from B.C. 300 to A.D. 1300 at least. Though N. M. Penzer has shown the distribution of the custom in India, Babylonia, Syria, Phœnicia, Canaan, and East Africa he has not cited any authentic instance of its existence in Northern India.

23. Food and feeding among the Austric tribes.

D. N. MAJUMDAR, Lucknow.

Every stage of economic life has its peculiar problem of food supply, and the solution of it, as well as the nature of the remedy, determines the social organization of the group. The changes in the economic environment of primitive tribes in India, and the manner in which the tribes have responded to these changes. How social differences between groups are accentuated by differences in food and occupation, and how common diet and common occupation reduce the barrier between different groups with unlike caste appellations. The supersession of customary rights in the forests, and the desire of the tribal people to follow Hindu practices, have meant an arbitrary restriction of tribal dietary. The formation of classes in Kolhan, and the perpetuation of class distinctions by introducing changes in the dietary. Characteristic features of the dietary of the different classes of people in Singbhum. The methods of preparing food and the *tabus* connected with them. Examination of the menus of the Hos and comparison with those obtained among the Caste Hindus. Feeding in Kolhan. How children are taught to partake of the tribal diet. Diet and vitality.

24. The principles of Khasi culture.

DAVID ROY, Shillong.

The Khasis are the people whom we now find on the series of picturesque hills of Assam, which rise from the narrow valley of the plains of the Brahmaputra river on the north and the plains of the Surma on the South. Sir George Grierson says that linguistic evidence points to tribes who still hold the hill country of the lower and middle Mekong and of the middle Chindwin, and the Khasis, as islands of Mon-Khmer origin, standing out amidst seas of alien peoples.

Women among the Khasis enjoy a position of unusual dignity and importance. Khasi society is organized on a matriarchal basis. Their idea of the State is that of a limited monarchy.

The Khasi interpretation of the human race is Mother-Son—'from the woman sprang the Kind'. Origin of the exogamous Khasi groups.

The Khasis' conception of God is that he is the Creator to whom all obeisance should be paid, but for man's acts of omission and commission there are forces inexplicable, except as lesser forces which cause all the sickness and calamities in the world. This accounts for the Khasi divination to find out the cause and propitiate these forces. Hence calamities are deified as evil or negative influences against which they must protect their person by sacrifices, and the beneficial forces are idolized as good spirits and deified in and through visible objects or fetish for the perception of the senses. But man through God rises supreme to all these forces and calamities, and no force or calamity can follow him after death, hence the necessity of proper sacrifices over his person through some tangible part or portion of his body or person, hence the collection of his bones in family cairns.

The legends of families springing from a fish which turned into a woman, or an ancestress found while in the care or protection of bamboo clumps, give rise to these objects being regarded as a Totem and treated as a Taboo, and this ultimately gives rise to clan names and the formation of exogamous groups.

25. Rules of avoidance in Bengal—an analysis.

NIRMAL CHAKRAVARTI, Calcutta.

26. The concept of disease in Austric culture.

D. N. MAJUMDAR, Lucknow.

The various agencies that are believed to cause disease among the Austric tribes. The methods of diagnosis and treatment of diseases. 'Dukidanal' or the examination of urine, and the study of reactions in the urine by adding a few drops of castor oil and other reagents, furnishes an important popular method of diagnosing disease. How 'Dukidanal' assists in the detection of diseases due to the administration of 'Najom' (poison) and 'tiji' (bacteria). The rôle of the 'Najomadani'. Witchcraft and diseases. The Deuri and the Deonra amonsgt the Hos and their methods of divination and treatment. 'Bonga Nam', 'Rum Nam', 'Patki Beur Nam', 'Bawa Nam', 'Danda Nam', and 'Sunum Nam' and other methods of divining causes of diseases. The methods of propitiation and sacrifices. Through contact with the outside world, the experience of life outside their habitat and through the medical aid given in certain centres, the tribal people now find it possible to explain many of the diseases which they are heir to as due to natural causes (which include the modern medical theory and all injuries obviously inflicted by material agency). The present-day attitude of the tribal people is to try all known and unknown methods in dealing with diseases, so that one or other may prove successful.

27. The spirit of Bongaism.

D. N. MAJUMDAR, Lucknow.

The cultural contact of the primitive tribes in Chota Nagpur with the Hindus and the Christian Missions has led to a miscegenation of culture and the borrowings of many traits, even though it is true that the latter have undergone some modifications in accordance with the spirit of their own cultures and the pattern of their social structure. The influence of Hinduism and Christianity on the religious life of the tribal population. The causes of conversion. The tribal pantheon includes mischievous and malevolent spirits, which are not indigenous to their religion but are borrowed from neighbouring cultures particularly from the lower strata of Hinduism. Most of the 'Bongas' are borrowed or invented by the Deonras to suit the pattern of social life. The malignant 'Bongas' of the Hos are mostly derived from the Oriyas. The conception of power in Austric culture. The distinction between 'Bonga' and 'Buru'. The division of function between the village Douri and the Deonra. The processes by which alien gods are introduced into the tribal pantheon. The value of dreams as a means of interpreting the rôle of the gods and spirits. The nature of the dreams, which suggest the interference of spirits both alien and indigenous, explains how the association they make of their gods with the foreign elements in the population is not accidental, but is engendered by a habitual mental process which attributes all their miseries to the presence of the foreigners known as 'Dikus'. How adoption of alien gods and spirits has forced their own tribal gods into the background. The belief in life-substance and the methods by which it is augmented. The importance of religious tabu. How tabus affect matrimonial alliances. An analysis of the present-day attitude of the Austric tribes to religion and all that is sacred to them.

28. Diseases and medicines among the Bunas of Bengal.

M. N. BOSE, Calcutta.

Conception of disease and its origin among the Bunas. A description of the medicines (roots, herbs, drugs, etc.) used by them. Names of the diseases.

29. The comparative study of law and justice of the Chirus, Koms, and Kabui.

A. SEN, Calcutta.

30. Conceptions of kingship and succession in the Hindu-Buddhist polity.

J. C. DE, Colombo.

In this paper the author examines the political conceptions of the period of Hindu renaissance from the fourth to the tenth century A.D., from epigraphic materials. Some of these conceptions centre round the different classes of rulers. First, the ruler is considered to possess the status of a divine or semi-divine being. Secondly, we find some rulers called 'devas', and their queens 'devis' or 'mahadevis'. Thirdly, a title 'Bhattaraka' is used both with reference to kings and deities. Fourthly, comparisons are drawn between divine and semi-divine beings and rulers, and some of these are very elaborate. Fifthly, royal descent is traced back to divine and semi-divine beings. Probably because of the reaction of *politik* on *staatslehre*, hereditary right follows as the natural corollary of divine right.

31. Several aspects of the Assamese theory of the divine right of kings.

J. C. De, Colombo.

Hindu Purana literature tells us that 'the mighty sovereign' of the Yavanas, Bhagadatta, was the overlord of Muru and Naraka. This Naraka is said to have been born of the earth (bhumi), his father being the great God Vishnu. Later on, the kings of Kamarupa claimed descent from Vasumati, the Earth-goddess, and sometimes added 'deva' (god) after their names. The triumphs of the Ahoms over Hindu princes enabled them to continue the theory of divine descent for themselves. We notice that (1) one of the ancestors of the Ahom kings 'ruled over heaven'; (2) they claimed descent from the divine Khunlung and Khunlai; (3) Chau or Chaw denotes both king and god; Pha may be equivalent to God, heaven or king; (5) the king is called 'svargadeva'; (6) the king conducted personally, and took part in, religious ceremonies. Thus the divine nature of the office was manifest in diverse ways.

Section of Agriculture.

President :—A. K. YEGNA NARAYAN AIYAR, ESQ., M.A., Dip. in Agri. (Cantab.), N.D.D. (Eng.), F.C.S.

Presidential Address.

SOME ASPECTS OF SCIENTIFIC RESEARCH AS APPLIED TO THE IMPROVEMENT OF INDIAN AGRICULTURE.

FELLOW DELEGATES, LADIES, AND GENTLEMEN,

I feel greatly honoured by being called upon to be the President of the Agricultural Section of this the 23rd Session of the Indian Science Congress, a position which in the past has been occupied by many a distinguished member of the agricultural services in India or other scientific workers of eminence who have made contributions of outstanding importance to the progress of agriculture in this country. It is with considerable diffidence and almost a feeling of trepidation that I have entered upon my duties and undertaken to deliver the customary address on this occasion to an audience composed of, on the one hand, eager young scientific workers, most of them specialists in their respective branches of science and, on the other, of the doyens of the agricultural services who add to their deep scientific knowledge the wisdom born of extensive and varied experience. If I feel qualified at all for this task, it can only be by my long service of nearly 35 years as an agricultural officer and that fortunately with one of the foremost Departments of Agriculture, viz., that of the Mysore State, a service dating back to the time when many of our Provincial Agricultural Departments were either non-existent or existed only in a rudimentary form. To the rôle of this general-purpose agricultural officer, if I may call it so, it has been my recent privilege to add that of an onlooker which enables one not only to see most of the game but also to describe and criticise it somewhat with greater freedom than otherwise.

Agricultural research and the demand for quick and practical results.

Great changes have taken place during this period in the expansion of the Departments, in the bulk and variety of scientific work and, what should be most gratifying to all, in the extent to which improvements have taken place in the agricultural practices of the country, and the ryot has responded both to a changed environment and to the efforts of the Agricultural Departments. The extent to which the efforts of the Departments whether in the field or in the laboratory result in immediate practical advantage

to the ryot is certainly a measure of the success of our work. This feature indeed is peculiar to the section of agriculture, viz., the attainment of results which will be of direct application in practice, profitable economically, and suitable to the conditions of the ryot and therefore capable of being taken up readily. Whatever other value researches in this section may have, however greatly they may redound to the credit of the workers as a matter of pure scientific research, however great be the results they may lead to with the progress of time, their value to the farmer as one of immediate practical application will constitute a most important test. The scientific worker in the field of agriculture thus works to some extent at a disadvantage not only in the matter of the choice of his subjects but also in respect of the manner in which it could be pursued. Many an alluring line of work which may open up in the course of any research has often to be strictly kept aside if it is not likely to be of any immediate practical value. The ryots' immediate needs are indeed supreme, and this touchstone has constantly to be applied and work sifted, designed and pursued only in the manner their needs may dictate. Many a scientific worker in this section should, no doubt, have felt this factor both cramping and irksome and should probably have envied his brethren in the other fields with their spacious freedom to pursue any line of work they like untrammelled by such considerations. But the advantage is not all on the side of the worker in pure science. The work of an Agricultural Officer, if found to be successful judged by this severe and somewhat cramping test, leads to results which cannot but be gratifying even to the most blasé and high placed aristocrat of the service. Increased production, saving of immense losses, increased comforts, more money in people's pockets and the country's increased prosperity—it is these which follow in the wake of such a piece of work, and what greater satisfaction or reward can one attain than the feeling that he has been the author and architect of such a change. These are the very results which have already been attained in a large measure, thanks to the band of workers in this section all over the country.

This matter of immediate practical benefit to the agriculturist constituting the most important objective of the work in this section has to be emphasized for an additional reason also. I refer to the frequent criticism from the public and their representatives in the different Legislative Assemblies of the work of these Departments, asking in effect to justify one's existence and to show value for the taxpayers' money. I do not know if any other department of Government, where scientific work is carried on, is subjected to this kind of examination and of which quick results such as will impress the public are demanded. It has been the fate of all the Agricultural

Departments from their very inception, but as time goes on and under the new form of Government, this test is bound to become severe, and it will require all the nice discrimination possible in those responsible for planning the work of the Departments to see that the claims of such lines of work as promise immediate results are fully met without at the same time neglecting the claims of work of a somewhat prolonged character or sacrificing the accuracy and reliability that only tests carried out over several years can guarantee. As a matter of fact, the need of this nice balancing has been fully realized and has all along been the policy of all the Departments, as the results achieved so far, and which I will describe presently, will amply demonstrate.

Welcome to H.E. the Viceroy Lord Linlithgow and a tribute to the services of the Howards.

Before proceeding to give you such a resumé, let me refer to the joyful news of the appointment of Lord Linlithgow as our new Viceroy—an appointment which every one interested in the agriculture of this country from the humblest ryot to the high officers of the various Agricultural Departments should hail with unmixed pleasure. His Lordship comes to us with a fund of knowledge and wisdom and ripe experience in all the aspects of agriculture and rural economy, in the intricacies of the various problems of agriculture as affected by trade, industry, nationalism and administrative exigencies, with a thoroughness of conviction and strength of views gained as the result of practical experience and of innumerable conferences, surveys and commissions, that we may confidently expect that an era of active State help and prosperity is dawning upon Indian Agriculture. Witness the report of the Royal Commission on Indian Agriculture over which His Lordship presided and to whose great ability and love for the agriculturist, it is a monument. Witness again the report of the Linlithgow Committee in England on the 'Distribution and Prices of Produce' with its accurate diagnosis and drastic recommendations. Fortunate indeed is Indian Agriculture at this juncture, and we, members of the Agricultural Section, have to congratulate ourselves on the happy event.

I would also recall to your mind the fact that we are holding this session of the Congress at a centre which has a special interest to agricultural workers. Indore and the Institute of Plant Industry will always be associated with the name of two talented workers in agricultural science, who have done yeoman's service to the cause of Indian agriculture. I refer, of course, to Dr. Howard and his late talented wife Mrs. Gabrielle L. C. Howard. Their services and work were exactly of the kind that I briefly indicated as required of most agricultural officers—the happiest combination of science and practice. They won a name not only for their scientific work, but a still

higher name for the practical results which they achieved. Their Pusa wheats now grown on millions of acres, to mention only the most noteworthy achievement, will long keep their name alive throughout the vast North Indian continent. Let us remember their honoured names with pleasure and with pride on this occasion.

Agricultural improvements effected in India—a resumé of 25 years' work, with special reference to Mysore State. (*a*) Improved agricultural implements.

I shall now give a brief resumé of the extent to which agricultural improvements have been taken up during the last quarter of a century, and in doing so will crave your indulgence if I confine myself to the State of Mysore. For one thing, that is the area I am intimately acquainted with and can speak with authority upon and for another, it will probably be a fair representative sample of what has been achieved over the other parts of India as well, and would therefore serve to illustrate my main theme that the work of the agricultural departments has led to very marked practical results. Taking implements and machinery first, there are now over 23,000 improved iron ploughs in use throughout the State, a number which is steadily increasing year by year. It was not after all very long ago that the opinion was generally held that it would be absurd to think that the Indian ryot would purchase and use ploughs costing Rs. 15, and yet these ploughs cost anywhere from Rs. 17 to Rs. 35 depending upon the pattern. The local manufacture and repair of ploughs is a growing industry both in our Government workshop and private foundries in and outside of Mysore. I may refer only to the names of Messrs. Kirloskars, Messrs. Cooper and Messrs. Burns & Co., to give you an idea of the growing magnitude of plough works in India. In the matter of threshing, the practice of having it trodden out under the feet of oxen which used to be universal has been almost replaced by the simpler, less laborious and more convenient method of threshing under a stone roller using only one pair of bullocks. Every kind of grain grown in the State, whether ragi, jola, navane or paddy. is now threshed by this simple method and there is no threshing floor where one or more of these rollers is not in evidence. Cane milling is being carried out with more and more efficient iron mills. Sugarcane mills of the Nahan Foundry in the Punjab, and those made locally on somewhat improved lines, have been largely popularized and there are now hundreds of these in use. Of power-driven sugarcane mills, worked by oil engines or electric motors there are a fair number already; the electrically driven mills are sure to increase in number, as most parts of the State are now being supplied with electricity for lighting and for power. The manufacture of dual purpose mills, which are of the bullock-driven type but with a detachable power attachment, and which

can therefore be used for bullock drive or power drive according to circumstances, is a promising development worthy of note. The use of pumps and engines for lift irrigation from wells and other water sources has assumed great importance. They number at present 453 comprising pumps driven by oil engines and those driven by electric power. The electrification of rural Mysore is indeed effecting a transformation of the country side; the old world grinding stones for grinding grain into flour are giving place to centralized electric driven flour mills, the hand-looms are going out and are being replaced by power looms in all the important weaving centres, and electrically driven pumps raise water from wells where patient oxen used to toil at creaking mhotes. Oil engines used to be the motive power until very recently, some of the installations being fairly large comprising 12 H.P. engines and 4″ centrifugal pumps. One single village alone has six such installations and all of them are looked after and worked only by the ordinary villager. Time was when the peasant was deemed incapable of using a screw driver or a spanner, and yet we can see to-day this astonishing spectacle of the common village lad managing efficiently not only the daily running of such an installation, but also the ordinary cleaning and overhauling and petty repairs. The Well Boring Department has been a very helpful auxiliary, and with deep well pumps and electric power the ryot is enabled to tap and utilize very much deeper sources of irrigation water than can be thought of with his ordinary well sinking methods or water lifting appliances.

(*b*) Manures.

The progress in the use of concentrated manures and artificial fertilizers is a really remarkable feature. That anything could be used as manure, other than the excreta of animals and ordinary village refuse, was almost unknown except among the coffee planters until the department came on the scene. Through field and pot experiments, demonstrations on ryots' fields, propaganda through ryots' meetings, the newspaper press, financial assistance of Government and other efforts, the popularization of oil cakes and other artificial fertilizers, nitrogenous, phosphatic and potash fertilizers, has gone on to such an extent that these latter are now sold even in village shops like any ordinary commodity; and yet there was a time not long ago when even the free supplies made for purposes of trial remained unused, the packets being kept intact, safe and unopened. The popularization of artificial manures is indeed a remarkable development throughout India, as can be seen from the import figures relating to artificial fertilizers, which rose from less than a thousand tons in 1908-09 to the record figure of 78,000 tons in 1929-30, though there has been a fall to about 50,000 tons in subsequent years owing to the depression. I may also refer to the utilization of wastes by the making of composts in which the

City Municipality of Mysore took the lead, and of which something like 12,000 tons were supplied during the last four years from the Sewage Farm of that City. Green manures too have been widely taken up, so much so that the trade in the seeds of sun-hemp in Mysore and of Kolingi—a wild indigo in Madras, are now of respectable magnitude.

(c) Improved varieties of crops.

It is in respect of crops, however, and of the work of the plant breeders that the changes which have come about amount almost to a romance. Speaking for the whole of India we may note that the new wheats evolved by the Howards at Pusa are now grown over an area estimated at 5½ million acres The numerous new strains of cotton evolved to suit different tracts and purposes of the Punjab, the improved varieties of the best cotton areas of Bombay and the Central Provinces and the Cambodia Cotton and other improved strains of South India, all these in the aggregate cover something like 3½ million acres at present. The Coimbatore sugarcanes have all but displaced the local canes in Upper India and have even overflowed into the other continents. In respect of thick canes, Mysore takes the lead, and the many excellent varieties evolved by the Mysore Department cover not only the Mysore State but have been taken up in the best cane areas of Bombay also. The G.E.B. 24 paddy of Madras has become one of the most favourite varieties of paddy in South India including Mysore, while in the latter State the new strain of ragi H. 22 has all but displaced the local strains in many districts. The same story can be told of the varieties of groundnuts, Spanish and Small Japan, which mature in about 3 months' time and which have an erect and bunched habit of growth, easy of harvest in contrast with the old trailing varieties which take about five months to mature and which are expensive to harvest. The advantage of easier and less costly harvesting and the possibility of raising an additional crop in the same land have been greatly appreciated and have consequently led to their cultivation over very extensive areas in Mysore, Madras and Southern Bombay. In fact every one of the Departments of Agriculture in India can claim one or more notable achievements in this particular branch of work, and the total all-India area under all the improved varieties of different crops is estimated at nearly 14 million acres. The money value of these improvements will be a staggering figure if it is properly and fully computed.

(d) Remedial measures against plant diseases and insect pests.

In respect of plant diseases, the spraying with Bordeaux mixture of the areca nut against Koleroga, and recently the use of the same material against the leaf disease of coffee in Mysore, are very striking illustrations, and have I venture to think no parallel. The lot of the ordinary areca garden owner of the malnad of Mysore is

cast amidst nature's hardest conditions; situated amidst hills and jungles in a tract with a very sparse population and consequently with a great scarcity of labour, with every kind of work having to be done by manual labour including the carrying of manures and produce, with a torrential monsoon rainfall which in certain parts reaches even 300 inches and practically bottling up the tract during this season, and the harvest of the produce and the spraying of the areca bunches being a hazardous operation almost in the nature of an acrobatic feat, the average areca garden owner, illiterate, poor and steeped in debt, is an object of great commiseration. And yet the remedial measures devised by the Department have appealed to him so greatly and have meant so much saving and relief that spraying has been taken up universally. There is no garden owner, however poor he may be and in whatever remote and inaccessible parts his garden may be situated, who does not keep two or three sprayers in regular use, buying his annual requirements of copper sulphate, casein and lime, and the needful repair parts, and carrying out the spraying work almost religiously. I think I am justified in saying that this has no parallel anywhere. Back of this result is of course an immense amount of departmental work in the shape of research, experiment in the laboratory and in the field, propaganda, and last but not the least an efficient sales organization. A loss of one-third of the crop may be said to be the result of an ordinary visitation of the disease; often times the loss greatly exceeds this proportion. Even at that rate the money value will be easily about five lakhs of rupees, all of which is now saved by this work. Against the leaf disease of coffee—Hemelia vastatrix—the same remedy has been recommended, and has been taken up quite extensively by coffee planters both European and Indian. The popularity of spraying may be realized from the fact that there are 8,500 hand-sprayers now in use, in addition to 500 large sprayers of the D.S.P. pattern and five motor driven sprayers in the State. The value of the annual sales of copper sulphate, lime and casein generally amounts to over Rs. 50,000, which is exclusive of the quantities bought by the planters direct. This control by means of spraying bids fair to become very widespread in the coffee tracts and areas outside of Mysore as well where they have now been in use for some time. Many a little improvement in this extensively used Bordeaux product introduced by the Department may also be referred to here, such as the use of local oils like linseed oil and gingelli oil as a substitute for the casein in the mixture, and of the use of small quantities of jaggery with the mixture to keep it from flocculating and subsiding. The latest of these spreaders to be tried with success is sugarcane molasses from the sugar factory.

In the section of entomology, the South Indian Departments can easily take credit for that most spectacular achievement,

viz., the eradication of prickly pear. It is now a familiar story that Australia after prolonged, persistent and costly efforts in which every possible method of control was attempted, such as cutting down, ploughing up, smothering with tanklike tractors, burning out with mechanical fire throwers, finally succeeded with the humble cochineal insect in exterminating the pest and reclaiming vast areas which had been overrun. South Indians were not slow to take advantage of this discovery and the insect was promptly introduced here. The result has exceeded the most sanguine expectations, and although it is hardly ten years since the insect was introduced, the prickly pear has all but disappeared from the country side. Giant bushes and impenetrable jungles of prickly pear have given way and perished leaving only their dead shrivelled skeletons to strew the ground, while a little fire finishes up these remains. A clean-up of this vast and unprecedented character which cost no-body anything has struck the ryot certainly with amazement. Looked at from the point of view of reclaiming much valuable land for cultivation or grazing, or from that of village improvement by ridding them of such a serious pest, it has been a great work. The fact that it costs nothing at all makes a great appeal to the ryot. This is in fact the method of pest control, which he would strongly advise us to pursue in respect of all crops pests ; not your sprays and washes and dusts, nor your handpicking or your light traps and trash-traps. That is quite a natural desire, one only wishes it were possible. It incidentally shows what great possibilities await this method of biological control, directly as in the case of this cactus or indirectly as in the case of insect parasites.

Another line of activity in which really remarkable progress has been attained relates to the popularization of inoculation against cattle diseases. A most intensive campaign against rinderpest has been carried on for some years now in Mysore, with the serum alone method in the beginning and now with the serum virus simultaneous method. The success of the campaign has been most gratifying as there has been a continuous and steady decline in the mortality, which encourages us to hope that we may be able to banish the disease altogether from our midst. Similar activity prevails in respect of other cattle diseases as well, and the work is now being cheapened and speeded up consequent on the opening of a serum Institute in the State where most of the sera and vaccines required by us are now manufactured. The point of interest for our present purposes is the change in the attitude of the ryot from one of indifference and even hostility to one of eager welcome and co-operation.

The above resumé amply demonstrates that the work of the Agricultural Departments in India has resulted in a measure of practical and immediate benefit to the agriculturists, the money value of which will run into crores of rupees. That

the ryot should have taken up such improvements strikingly shows that he is not at all slow to respond, and such an attitude should put heart into every worker in the field of agricultural science.

An example of quick results and the story of the Sugar Industry in Mysore.

Now most if not all the items of work that have been referred to so far have been the result of many years of endeavour, covering more or less a period of some fifteen years at least. I shall now deal with a remarkable instance of improvements having been taken up with surprising rapidity, overnight one might say, compared with the prolonged and strenuous period covered by the former. I select it for a separate description because it is full of lessons on each of which it will be profitable for us to pause and consider. The subject relates to the development of the Sugar Industry in the Mysore State.

The Mysore State has, as you may be aware, one of the largest irrigation projects in India in what is called the Krishnarajasagara project. An immense dam across the river Cauvery impounds water which serves the double purpose of ensuring a sufficient flow of water during all months of the year over the waterfalls at Sivansamudra, where the hydro-electric power is generated, and is secondly designed to bring under irrigation something like 1,50,000 acres of dry land. In 1932 the scheme was sufficiently advanced to admit of giving irrigation to certain tracts and this partial completion of the project synchronized with that great landmark in the progress of industry and agriculture in India, namely, the granting of protection to the sugar industry. How quickly the industry responded to this stimulus all over the country and factories began to be started is now well known. Mysore lost no time in taking advantage of the situation. An up-to-date factory to crush 700 tons of cane at the outset, which has recently been expanded to handle 1,400 tons of cane, was decided upon and the cultivation of the sugarcane over the necessary area was taken on hand. The tract of country which came under irrigation was purely dry, cultivation was precarious and the ryots poor, and agriculture generally backward. The cultivation of cane was not only a novelty but being a costly crop to grow requiring special knowledge was attended with considerable difficulty. And yet over an area of 3,000 acres, which has at present expanded into 11,000 acres, you see every acre ploughed and prepared with improved iron ploughs and cultivators; the same variety of cane H.M. 320, one of the best varieties evolved by the Department, planted throughout, every acre manured with artificial manures composed of sulphate of ammonia and superphosphate, in many cases supplemented by a basal dose of the compost from city refuse I alluded to in an earlier part of this paper; the same method of application of the manure, the same

methods of the earthing up and of irrigation, all of a special kind recommended by the Department are adopted throughout ; so likewise are the methods of ratooning the cane. All these are improvements which would have taken years to accomplish under ordinary circumstances. That in this tract they should have been adopted so quickly and on such a large scale has been possible only by this combination of a profitable industrial undertaking with agricultural enterprise. It has been possible furthermore for the factory to finance the cultivation of the ryots' cane, as the amount advanced is recovered easily from the price paid for the cane which under contract is to be supplied to the factory. The system ensures a ready outlet at reasonably fair rates for all the cane grown by the ryot on the one hand, and on the other the cultivation of the cane itself in the most efficient way, variety, cultivation methods, and manuring all being the best and most adequate, because part of the sale proceeds of the cane reaches the ryot only in the shape of implements, seed cane and manure and a small advance for cultivation expenses, and not as ready money paid in a lump sum which may not be spent on the crop but may be utilized for their purposes. In this manner since the factory was started these cane growers have been supplied with 1,900 improved ploughs and 4,000 tons of fertilizers. The area includes one large experimental farm of 600 acres for all experimental work on sugarcane and for the supply of seed cane, and three large Government sugarcane farms (since transferred to the management of the Sugar Company) about 2,000 acres in extent which in addition to growing cane for the factory serve as demonstration farms as well. The experiments on the Government farm comprise manurial trials, the breeding and testing of cane varieties, improvements in cultivation such as irrigation and drainage methods, the testing out of remedial measures against sugarcane borer, principally by the large scale rearing and releasing of parasites, the testing of a number of crops which can be recommended as rotation crops with sugarcane, problems connected with ratooning and so on. In the factory itself, in addition to the manufacture of sugar as elsewhere, an up-to-date distillation plant designed to manufacture spirit of all strengths, both potable and absolute alcohol, and thus to utilize molasses to the fullest extent for industrial alcohol, forms a most important adjunct. Trials for the utilization of molasses for manure on a large scale and also as a road binding material have also been taken up, and the results of this if satisfactory are bound to have an important and far reaching effect. The tract itself has been opened up by many roads and cart tracts, a large outlet for the ryots' labour has been created, and the exodus to the cities and plantations considerably reduced. The ready money returns from the sugarcane cultivation is helping the ryots to extinguish their debts and will soon enable

them to rise out of their squalor and sordid poverty and to arrest the decay of the village. The reaction on other activities and trades, catering, house building, transport by rail, motor and cart, all of which have been greatly profited, has been quick and striking ; while in a larger sphere the income to the Government, both directly as the major shareholders of the Company and indirectly by way of other earnings, has been beyond expectations, ushering in altogether an era of all round prosperity.

The need for linking up agriculture with a manufacturing industry.

Now the first lesson I would draw from this picture of agricultural development is the linking up of an important manufacturing industry with agriculture, mutually dependent and each sustaining the other in a form of colossal symbiotic existence. Through the door of a profitable outlet for his produce, the ryot has been quick to take to agricultural improvements which otherwise would have taken years of effort to bring about.

It is true that the success of the sugar industry is due in the first instance to the protection which has been granted to it ; but carried out on the proper lines, under efficient and up-to-date management, and given the necessary facilities for the full utilization of the bye products, it is reasonable to expect that the industry will in time be able to dispense with the protection.

It is therefore the need of industries like the sugar industry which will directly utilize the products of agriculture in the country that I would strongly emphasize the need for an alliance of this character between agriculture and industry. This need for such an alliance will become more and more keenly felt as the years go on, because the interests of the agriculturist are likely to clash with those of the industrialist, where the former depends upon an export market for the raw produce which he raises, and the local industrialist has to compete for this raw material with his wealthier overseas rivals who may pay a better price. Substantial State aid may be necessary in the shape of protection, subsidies, railway concessions, Government patronage of local manufactures to the exclusion of foreign ones and so on. But no efficient way of increasing the prosperity of the agriculturist can be thought of than this combination of agriculture with industry, for that alone will increase the earning power of the ryot. Without such a direct increase in the ryots' income no scheme of rural uplift will bear fruit.

The example of the Tobacco industry in Guntur.

In this connection I may also give you another instance of the beneficial results of this happy combination, and this relates to the cultivation of American tobacco in the Guntur District of the Madras Presidency. With the advent of the Imperial Tobacco Company into this tract with the

object of cultivating American tobacco and adopting flue curing methods and preparing leaf fit for manufacture of cigarettes, the agricultural prosperity of that neighbourhood has jumped up by a bound. The ryots' income rose, cultivation methods have greatly improved for the better, while curing methods have undergone a radical change. With curing came proper conditioning, and the industry expanded to such an extent as to be able to export cigerette tobacco to Great Britain and compete with similar tobacco from other countries like the United States or Rhodesia. The tract now grows about 35,000 acres of American tobacco and some 80,000 acres of local tobacco. Of flue curing barns there were 1,601 last year, as against 253 during the year 1932, and conditioning has been taken up even by the local landlords. The magnitude of the organization itself is a most impressive spectacle in the tract, despite even the present day depression. It may be predicted that a similar measure of prosperity will accrue to the rubber growers of Travancore as a result of the local manufacture of rubber goods, which has been undertaken by that Government; although the growing of rubber is not a peasant occupation, but is in the hands of large capitalist companies. On a small scale the manufacture of casein in the butter making dairies of Western India has acted as a great fillip to dairying in that tract and raised the income of the farmer.

Desirability of organizations like the Indian Central Committee for other important crops.

It is needless to multiply instances, it is easy to see that this combination of the two interests is necessary, and if the efforts of the Department are to bear fruit and benefit the ryots quickly and widely, the fertilizing effect of this combination is necessary. I have often thought that an organization like the Indian Central Cotton Committee, comprising as it does the grower, the scientific worker, the trader and the manufacturer, all the interests concerned in fact, will be of great advantage in respect of all the other important commercial crops of the country, whether it be sugarcane, oil seeds, tobacco or other crops. A practical bent along the most promising lines of investigation can always be expected to be given by the trade, while the alertness of the manufacturer can be trusted to bring about the relative manufacturing industry to furnish a ready and paying outlet for the crop grown. No more valuable allies than these, viz., the trader and the manufacturer, can be thought of to enable the scientific agricultural worker in his endeavour to help the grower. For this same reason let us hope that the newly created Central organization for Industrial Research will bestow special attention upon the industrial utilization of the products of agriculture, whether they be field crops, fruits, vegetables, milk and milk products, dyes or perfumes, and whether they be the main products or the bye-products.

The Sugar Industry and the problem of molasses utilization.

The next lesson I would touch upon with reference to this development is the subject of the profitable utilization of the bye products of the sugar industry, principally molasses. Molasses I need hardly explain can be put to a variety of uses—cattle feed, distilling into spirits of various strengths for the production of potable and industrial alcohol, for carbon dioxide, for fuel by itself or made into briquettes with coal dust, begasse, cotton mill sweepings, or other waste material, for manure, and lastly for the use to which it is being put in Mysore as a road material much in the way tar is used for similar purposes. At the present time the most profitable use is certainly the manufacture of alcohol. Here and there in the country distilleries form an adjunct to sugar factories, and potable alcohol is being produced. But the amount of molasses that could be absorbed by this method is very little indeed compared with the huge production both present and prospective. It is in the manufacture of industrial alcohol as a partial substitute for petrol that we must look to a method of utilization that can be at all adequate. It is needless for me to stress the importance of this product to India in these days when all countries consider it of vital importance to be self-contained in respect of their petrol and petrol substitutes, and when our own country has to import all the petrol that it requires. Nor is it necessary to picture to our minds the great development industrial and otherwise that is bound to follow in the wake of the local manufacture of industrial alcohol. Furthermore, without a profitable use of this or other kind for this important bye product, it is doubtful if the sugar industry will at any time be able to dispense with the need for protection, and should the protection be withdrawn or materially reduced, the industry will run the risk of reverting back into its pre-protection decay leaving behind a trail of incalculable loss and ruin. A product like molasses does not lend itself to long distance transport and practical considerations will necessitate its utilization at or not far from the factories. The Mysore State has fully envisaged the needs and possibilities of the situation and has very wisely added a most up-to-date alcohol distillation plant as an adjunct to its sugar factory, which may be expected to deal with its molasses for the production of industrial alcohol as a petrol substitute and incidentally furnish data of a most useful character for the benefit of the sugar factories throughout India. An export trade in molasses will not furnish a satisfactory alternative outlet for the product. For added to the difficulties of transport to the coast from long distances in the interior of the country is the uncertainty of an export market both as regards a remunerative price and the duration of the demand; it is doubtful, therefore, if the outlet can be relied upon as a satisfactory method of utilizing molasses.

The utilization of molasses as cattle feed and as a manure certainly affords possibilities in our country where we have an abundance of neither the one nor the other; both are moreover among the most crying needs of the country. One welcomes therefore the work already being carried on by scientific officers and by some of the factories themselves by way of experiments both in the laboratories and in the field as to the best manner in which it should be used for either purpose. We should be thankful to the Imperial Council of Agricultural Research for the grant which they have recently made for continuation of work on this subject, as indeed for numerous other schemes of investigation. Let us hope that these two methods of utilization which are directly of advantage to agriculture will be so developed that the factories themselves will deem it worth-while to have recourse to them for the profitable disposal of their molasses. But it will be some time before the results of the endeavours of both factories and scientific workers in these directions can materially solve the problem of molasses disposal. For one thing, in spite of promising laboratory experiments both in Allahabad and in Bangalore, field experiments on cane manuring with molasses have not given any striking indication in its favour. Practical difficulties in transport, in the manner of application, in the need for a considerable interval for weathering in the soil also militate against its use as a cane manure at present. The experiments will have to be continued, the effect on other crops will have to be tested, and the methods and time of application, the addition of other ingredients which may increase the efficiency of the molasses and other matters will have to be examined and tried,—all of which means time, at least several crop seasons. I may add in this connection that as a manure on alkaline soils for paddy growing the application of molasses at the rate of one ton per acre has yielded satisfactory results in Mysore and that this experiment is being continued. In respect of a prepared cattle feed like molasscuite the question of a cheap carrier or filler like begasse or shredded straw is not an easy one to solve. No factory has any over abundance of begasse to spare for this purpose after its fuel needs are met, and the shredding and cost of straw may make it too costly. Shredded groundnut husks and groundnut hay may be suggested for trial in this connection, and if these should be found to be suitable it will solve the problem in an ideal manner. The reason is that if groundnut should be grown as a rotation crop with sugarcane, as it eminently deserves to be, and as no doubt it soon will be on a large scale, then very large quantities of groundnut husks and groundnut haulms and hay will become available as a waste product, for which utilization as fuel or manure will be about the only method of disposal. But as an ingredient suitable for mixing with molasses as a cattle feed, it will become an

article of value, will add to the profits of groundnut cultivation, and will solve the problem of molasses utilization so that the cultivation of sugarcane and groundnuts will be mutually helpful and perfectly complementary not only on the field but also in the factory. It is earnestly to be hoped that investigations will be speeded up in both these directions and alternative materials and methods found out. The improvement of cattle, both milking and draft, is intimately bound up with the question of adequate resources of cattle feed, and we cannot neglect the opportunity now presented to us by this new and almost unlimited supply of a valuable feeding material.

Utilization of waste products.

While on the subject of bye products, I would state that scientific work with a view to finding out possible ways of utilizing certain waste products of agriculture is worthy of being taken up, as these may if successful increase the money return to the ryot from the crops concerned and also lead to the starting of new industries. These products are the husks of the arecanut, coffee pulp, the husks of over ripe cocoanuts, the 'stems' of plantains, groundnut husks, paddy husks and so on. Accumulation of these waste products is very large in the areas where these crops are grown and their disposal becomes a difficult and serious problem, even burning or using them as manure being found not always adequate or easy. Now and again some method or other is suggested more or less in a cursory manner such as the utilization of the areca husks for spinning, as tow or stuffing, coffee pulp for fermenting and plantain stems for fibre. Elsewhere the manufacture of cellulose and of furfurol is indicated as possibilities, but little has come out in practice An organization of the kind I have suggested on the model of the Indian Central Cotton Committee for other important crops will help in focussing attention on such matters as well. In any case the returns from farming are so low that the need for some profitable utilization of these waste products demands more practical attention.

'Quality' in crops and manuring.

I referred earlier in this paper to the growing popularity of artificial manures and to the significantly large imports of these manures into this country. When the present depression in agriculture lifts, almost the most important and immediate result will be a more extended use of these manures and a larger import. It will be a great advantage at this stage to bestow some attention on the question of the influence of manures on the 'quality' of produce. As you are aware the value of the manure is judged at present almost entirely by the total quantity of produce harvested whether it is paddy or groundnut or sugarcane or tobacco or coffee. What result any particular manurial ingredient or combination of ingredients may have on the quality of the produce has not so far received the attention

it deserves. Take the case of sugarcane for example. Will it be possible to increase the sugar content of the cane by special methods of manuring, so that we may add to the advantage of a high tonnage a higher sugar content also, leading thus to a larger outturn of sugar not only per ton of cane but also per acre? Will it likewise be possible by methods of manuring to increase the oil content or the proteid content or whatever else it may be which gives to any particular produce its special economic value ? To what extent will it be possible for us to alter the texture of the tobacco leaf and its burning quality, so as to make them more suitable and valuable for the purpose for which they are esteemed ? Or again can we improve the strength, colour or spinning quality of any particular cotton by methods of manuring ? Some of the Indian oilseeds which enjoy a tariff as against Non-Empire produce in the British market are said to be less in oil content than the latter and that on this account the trade favours these in spite of the higher duty. What a great advantage it will be if the varieties naturally suited to this country can by means of manuring be improved in their oil content need hardly be pointed out. Not long ago it was given out that the keeping quality of the hill plantains of Madras was markedly improved by a larger use of potash manures, which made it therefore more suitable as a commercial product which could stand storage and long distance transport. It has also been mentioned, you may remember, that manuring with cattle manure increases the vitamin content of certain grains and improves their productive capacity as seeds, while its exclusion has the reverse effect. To what extent have these statements been verified, and if true how can we amplify them and apply them to the case of all kinds of produce as well ? Will it again be possible by any system of manuring to improve the quality of coffee or tea grown in certain tracts to approximate to that of the best kinds ? Such work will necessarily have to be preceded by investigation to find out what exactly constitutes 'quality' in these products, so that it could be measured and assessed. Indications point to the possibility, at any rate they certainly do not shut it out, that many of these factors of economic value which we are considering respond to changes in manurial treatment. It is only in respect of the ash and similar ingredients in the seeds of crops that it is generally believed the composition is constant, irrespective of the manures applied. But the characters of economic value even in the case of the grain crops, oil seeds, pulses, and coffee are different from their mineral composition, and the possibility is therefore not excluded of changing them by methods of manuring. In the case of sugarcane and tobacco, it is not the seed but the stem in the one case and the leaf in the other which are concerned, and so the fact of the constancy in composition will not apply to these at all. In the case of the tobacco it is well recognized

that the chlorides of potash affect prejudicially the burning qualities of the leaf while the sulphate does not; that it is also possible to increase the nicotine content of the leaf by special nitrogenous manuring, and that further certain manures render the leaf harsh, inelastic, short and dry and less fit for the better class of wrappers. In rice and wheat, manuring with sodium nitrate in two or three doses and at particular stages in the growth is claimed to increase the nitrogen content in the grain. In the case of groundnuts potash manuring is claimed to increase, and its exclusion to reduce, the oil content. Potash manuring in some recent experiments in certain centres in the country conducted under the auspices of the Kali Syndicate is claimed to result in increasing the sugar content of the cane. Heavy manuring, especially with nitrogen, is generally believed to be prejudicial to quality in barley, and in the case of fruits and vegetables to the keeping quality and even to their taste. It is also common experience in the case of rice that differences in soil materially affect the quality, as superior fine rices of certain soil tracts often deteriorate, into an inferior or coarse kind when grown in a different soil. I mention these instances to show that work along these lines designed to find out if many of these claims can be substantiated and to what extent the quality of produce can be improved giving it a higher money value, is likely to lead to very useful results. It is possible that the action of manures on the characters of economic value in different products has in the past gone unnoticed in the innumerable manurial experiments conducted by the various departments on the different crops, because the performance at the weight-bridge alone has been the test of the value of the manures, while their effect if any on the quality has not been looked for.

Manures and soil constituents in relation to crop hygiene.

I shall now pass on to another aspect of the manuring problem to which it is time we paid some special attention; I mean the possible dangers of one sided manuring. It is a matter of general experience that on the large majority of Indian soils it is only nitrogenous manures that produce striking results and increased yields; phosphatic manures either do not result in any increased yields or do so only to a very small extent almost negligible in comparison with that of nitrogenous manures, and often not at all sufficient to cover the cost of the manures, and that where potash is concerned the case is still worse, the increase is very little if any at all, while in certain cases there is even a depression in the yield. Of course with certain soils, and with certain crops, the results may be somewhat different, but on the whole the general experience is as I have stated. The natural result therefore is a tendency to confine oneself more and more only to nitrogenous manures, to the exclusion of the phosphatic and potash manuring. It is only the nitrogenous

manures which pay, and it will be idle to expect a farmer to spend money on any manure which does not pay. Sulphate of ammonia is about the only manure which the ryot frequenting the sale depots goes in for, talks about the need for phosphate or potash in addition going practically unheeded. Such one-sided manuring is bound to have a deleterious effect on the soil and it should be only a question of time when this effect becomes felt on the yield of crops. Perhaps it is already affecting the crops through diseases, physiological disturbances and impaired ability to resist disease, or through a change in the quality of the produce or through other insidious ways which either are not sufficiently conspicuous or are attributed to other causes. Any injury to the permanent fertility of soils on any large scale is too serious to contemplate, and it is best we make endeavours in the early stage itself to prevent it, acting on the wise maxim 'a stitch in time saves nine'. It is therefore of importance that the effect of the fertilizers in other ways than mere yield be studied more systematically than at present, on the soils and conditions prevailing in this country, in which attention will be paid not only to the composition and quality of the produce and the effect on the vegetative growth, predisposition to disease or the incidence thereof and so on, but also to the soil reactions, root development, bacterial and other changes below the ground.

The action of compounds other than those usually considered of manurial value, such as various elements like manganese, zinc, boron, etc., is also worthy of study in this connection, many of these being at present reputed to act somewhat like catalysts in their action in increasing crop yields. The large volume of work which has already been done in other parts of the world encourages one in the belief that in one or other of these we may even discover remedies for some of the plant diseases which baffle us at present, especially those which are put down to physiological disturbances, viruses and so on, such as chlorosis, mosaic, spike disease of sandal, red leaf blight of cotton, etc. In fact, the rôle of even the ordinary soil constituents, either of a deficiency or of an excess of one or more constituents, in the causation or prevention of diseases of crops has not yet received in the country the attention it deserves, unless it be in respect of lime and of phosphoric acid about the latter of which there used to be considerable controversy at one time. Much less therefore has been the attention that these other elements, including the rare elements, have received. It may not be altogether fantastic to bring in the analogy of the relation between vitamins and the human system and apply it to the possible ultra-subtle action of various soil constituents including even the rare elements, in respect of these crop diseases, and to look to their action as a possible solution of the problem of the causation and the remedy for these diseases.

More attention needed for the study and combating of crop pests and diseases.

The problem of crop pests and diseases is indeed one which demands considerably more attention at our hands than many others, and its importance is bound to increase as intensive cultivation, large scale cultivation of commercial crops, and the growth of superior high yielding varieties evolved by the plant breeders, increases as the result of the efforts of the Departments. The plant breeding sections have so far been the most popular, as very striking results have been produced already and the prospect of equally striking results being yielded as the result of further work in the case of every crop is always bright and promising. Compared with the work of this character, the work of the Entomologist and Mycologist is somewhat discouraging; it has not been found possible to afford relief by way of simple and effective remedies for the large number of pests and diseases which are always with us and which levy a heavy toll on the income of the ryot. The losses in the aggregate will be beyond calculation and in many individual cases spell absolute ruin to the grower. More staff and more money have to be diverted to these important branches of work, if it be only to guarantee to the ryot what is indeed his barest due, let alone a sufficient return for the money and labour and enterprise he may invest in improved cultivation. Early in this paper I referred to some striking results achieved, viz., the introduction of cochenial to eradicate the prickly pear, and the spraying of Bordeaux mixture in the case of leaf disease of coffee and the koleroga of the arecanut. But of pests and diseases the number is legion and I do not know if there is a single crop in this country which is not subject to some serious disease or other; what has been accomplished so far, striking though it may be, is therefore nothing compared with what remains to be done.

The menace of the borer pest in the sugar industry.

Let me now refer to one or two cases to illustrate my remarks. The extensive cultivation of sugarcane for factory purposes, as the result of the recent development I described at some length, has brought in its train a difficult problem, viz., the sugarcane borer pest. Though this has always been with us and remedies suited to small scale cultivation have been devised and adopted with some success, this large cultivation on thousands of acres within a limited and compact area has brought in a new factor; added to this is the more serious one that cane is grown practically throughout the year in order to have as extended a crushing season as possible for the factory. What with cane planted in more than one season in the same year, and what with the cane ratooned, the crop is on the land always without any interval, creating ideal conditions for a continuous and uninterrupted prevalence of the pest. Borer attacking the young cane soon after it sprouts wipes out whole fields in bad

cases or creates numerous gaps, in both of which cases extensive replanting has to be done. Borer attacking fairly advanced cane ruins the top shoot, prevents further growth of cane and induces side shoots, reducing thereby not only the tonnage of cane but also the quality of the juice. It is easy to realize what this state of affairs means when it prevails over an area of something like 10,000 acres of cane concentrated in a compact area. Cutting out dead hearts, the catching of moths under trash traps, killing out the grubs in the seed setts by immersion in water have not been found adequate, nor can relief be sought in resistant varieties of canes, for none so far has been found to be sufficiently immune. Here therefore is a case where the method of control by the release of parasites on the pest, which can efficiently keep it under check or wipe it out of the area altogether, is indicated; as a matter of fact, in this cane tract in Mysore special methods have been devised to rear out the parasitic wasp (*Trichogramma minutum*) on a scale sufficiently large for release over the whole tract, and I would only emphasize here the desirability of our devoting more attention to this new line of attack, not only in respect of the cane pests but of others as well. I am glad to see that a serious note of warning has been sounded in this respect by that authority on sugarcane problems, Mr. Noel Deer, who states as the result of a survey of the cane crop in Upper India that the loss due to this pest may be put down as well over a crore of rupees per year. He also bears personal testimony to the 'spectacular and eminently successful' campaign of the parasitic method of control of the borer pest in Hawaii, and strongly urges a detailed and long continued trial of the same method in India. The possibilities of a recent development of the light trap methods which is being demonstrated and which is claimed to be successful against mosquitoes and other insects, deserve also to be explored, as indeed the possibilities of light in many forms. I may also add that in Mysore it has been found that the earthing up of the cane rows at a very early stage greatly reduces the pest and that the value of the method is being further tested.

Special Organization needed for disease research.

Many of the major crop diseases are sufficiently important and baffling that it will be necessary to organize a many-sided attack if I may call it so; I am particularly referring to the wilt disease of cotton and tur, to the red leaf blight of cotton, the spike disease of sandal (though this is not an agricultural crop) and such like; where its importance warrants it, not only the Mycologist, but the Chemist, the Entomologist, the Economic Botanist and the Agronomist should each attack the problem from his respective angle. Possibilities of electricity and irradiation with special rays may be explored with advantage. Those of us who have followed the work of Dr. Nehru in this new and fascinating field of

research must have strong hopes that very useful applications may become possible and even practicable with this new weapon, not only in the matter of increased crop yields but also of disease control. With proper arrangements for consultation, co-ordination and economical team work, it will, I think, be possible to elucidate these baffling problems and to devise suitable remedial measures much more quickly and satisfactorily than otherwise. A beginning has been made here and there in pursuing this method of joint investigation, but it deserves to be strengtnened and extended to all the major diseases.

The Control of weeds.

Before leaving the subject of crop pests and diseases, I should like to make a brief reference to the subject of weed control—I mean the weeds which in practice transcend the ordinary methods of cultivation. We seem to be still far away from the possibility of eradicating or keeping down the lantana, recent work being in one respect positively discouraging. You will remember what great things were at one time expected from the lantana fly and how efforts were made to import live specimens from Hawaii for breeding, multiplication and controlled release for trial in this country. These trials as you know showed that as destroyers of lantana the flies were poor performers and that the method was not of much value under the conditions of our country. It now transpires that the fly has been with us all along though at that time quite the contrary was believed, and the fact that the lantana still flourishes and overruns the country side finally decides the case against the fly as a lantana destroyer and puts it out of consideration. The water hyacinth on which also considerable time and attention has been bestowed continues to spread and still awaits a suitable method of eradication. An extraordinarily troublesome weed in the Mysore malnad is the Touch-me-not (*mimosa pudica*), which having spread in the jungle, waste places, grazing areas and all open ground has now for some years invaded cultivated fields and valuable areca gardens. With the pest around and about everywhere, no amount of careful cultivation on the part of the ryot can keep it off and it has become the despair of the people. The fact that so much of waste land has been overrun by the weed where it is no man's duty to spend money or labour for its eradication makes the problem more difficult. Another troublesome weed which is spreading with great rapidity in the districts of lesser rainfall is the thorny *Alternanthera echinatus*. The various means of weed control at our disposal at present, including spraying with weed killing chemicals, are not found adequate at all. It is to the resources of science that one looks for relief and I think that this subject of weed control with special reference to the ones I have named must receive more attention at our hands. I have not mentioned weeds like the Hariali (*Cynodon dactylon*) on the black cotton soils,

the bulb grass of garden lands and orchards or the parasitic weed striga of cholum fields, because they are confined to cultivated areas and are more or less amenable to the ordinary methods of weed control.

I shall now pass on to the subject of animal husbandry.

The Improvement of Cattle.

Looking back over the past thirty-five years I cannot help thinking that in the important matter of effecting improvements in the quality of our milk cattle or of our sheep we have been able to achieve very little. One reason certainly is the clash of the conflicting claims of different methods of cattle improvement. Opinions have been sharply divided on the merits of these methods, whether it should be by a selective process in the local breeds themselves or by cross breeding with foreign breeds, whether again the buffalo should remain and receive attention as a milk animal or should give place to the improved cow and recede to the background; such action as has been taken has therefore been only of an experimental and tentative character. I doubt if even now we are in a position to give a definite lead in the matter. Naturally, therefore, we have not been able to make any great impression on the dairy industry or on sheep improvement. There is the additional reason that the improvement of cattle even after a definite line of action has been decided is an extremely slow matter and requires the co-operation of enthusiastic cattle breeders. It is also mixed up with the question of raising fodder crops, of the improvement of pastures, of the conservation of fodder, and again of the disposal of the dead load of useless cattle and so on—recommendations in regard to all of which are beset with great difficulties in practice. Thanks, however, to the great demand for milk consequent on the growth of cities and the all but universal vogue of coffee and tea drinking among the people, dairying has received a great stimulus, and in this circumstance I have no doubt we shall find a most valuable ally; for the steadily increasing and assured market for milk justifies and leads to an adequate feeding of the animals under the stimulus of which even ordinary animals improve in their milking capacity. An adequate measure of feeding will always remain the foundation of cattle improvement, and a steady and lucrative custom for milk will ensure this most indispensable requirement. Already in and around the cities and in the outlying villages from which the city milk supplies are drawn, the quality of milking cattle both cows and buffaloes is decidedly superior, the performance at the milking pail alone being the test, irrespective of whether they are cross bred or local animals. There is such a great demand for good animals that cattle breeding whether in the villages or in the cities is surely though slowly responding to the stimulus. We have also made great strides in the sphere of veterinary science, in the preparation of sera and vaccines and

in the popularization of the inoculation of cattle in the villages. This is one great obstacle, considered almost insuperable, removed from the path of cattle improvement, and a matter on which the Congress as a scientific body can feel gratified. We can, I think, look forward to a considerable hastening in the pace of cattle improvement in the coming years.

Agricultural Marketing.

In the course of the above remarks I have confined myself almost entirely to the technical aspects of agriculture and the application of science to the crop raising part of the industry, and have not entered that alluring field of rural life and economy with which the adoption of many of our recommendations in practice is intimately bound up. The petty and scattered holdings, open fields, absentee landlordism, insecure tenancy and old established customs, rural credit and indebtedness, the marketing of produce, the low general agricultural level implied by mere subsistence farming, all set very effective practical limits to the carrying out of improvements, and are subjects to which I would fain make more than a passing reference were it not that I feel I am already exceeding the limits of this discourse. I shall however with your permission touch upon at least one among these subjects, viz., the marketing of agricultural produce.

As you are all aware, a section for marketing has been constituted under the Imperial Council of Agricultural Research in pursuance of one of the main recommendations of the Royal Commission on Indian Agriculture. The need for such an organization and the benefits that are likely to accrue therefrom are too well explained in that exhaustive report to require any reiteration here. The art of marketing is so different from that of mere crop raising, and involves such an amount of special knowledge, that the ryot is generally at a great disadvantage when it comes to converting his produce into money. Be he ever so good and clever and enterprising in getting the best returns in the shape of produce whether it be crops, cattle or milk, it does not avail him at the marketing end of his years' efforts. I am not referring to the petty malpractices, exactions and other abuses in the unregulated markets which are generally complained of, nor to the lag between the prices which the consumers pay and that which the grower receives. These are surely important enough, though the marketing surveys now in progress may bring out that none of the intermediaries are earning more than reasonable wages for services rendered or risks undertaken. I am referring on the other hand to the factors which affect both the producer and the merchant and which, as the result of these marketing studies and surveys, will have to be dealt with so as to benefit both. The scope for wider marketing, prevention of glut and diversion to other centres of demand, the requirements of the more paying markets, the notification of prices in the principal markets, attention to quality

in produce and grading, the holding up of produce, construction of store-houses, elevators and cold storage plants, assembling of produce and the cheapening of transport by road and rail, better regulated and less wasteful trade routes, facilities for long distance transport and even the larger questions of protection against foreign dumping will, I believe, be handled by the new organization which will thus so comprehensively organize marketing as to benefit not only the grower but the country as a whole. The need for such assistance even in normal times is obvious and has been frequently urged; but in view of the low prices and the serious depression in agriculture that has been prevailing, the organization has not been started a moment too soon. The surveys are an essential preliminary and should be exceedingly valuable, and should furnish precise and thoroughly reliable data which will incidentally decide the correctness or otherwise of many opinions based more or less on general impressions. Let us therefore welcome to our ranks this latest ally in the cause of Indian agriculture, and let us hope that the officers of this section will avail themselves of the forum which this Congress provides for discussion and exchange of views.

The World depression in agriculture and the rôle of science in the rescue.

I shall now bring this discourse to a close. The unprecedented depression in trade, industry and agriculture that has been the most deplorable feature of the last few years has hit no branch of human activities more seriously than the agriculturist, and the tragedy of it is that it should thus be the producer of the primary requisites of life that has suffered most. His fault is said to be not any slackness or falling off in his efforts, but the reverse, an over-zealous effort in fact and over-abundant production. The produce which his labours have taken a whole year to wrest from the soil is a drug on the market and unwanted. It is thrown into the sea, it is burnt in the fire or is allowed to moulder in warehouses, and this at a time when large sections of the human race suffer from hunger and cold and clamour for food and clothing. This curious paradox, ludicrous if it were not so tragic, has often been pointed out; but as to the cause and remedy doctors differ and the acutest brains are apparently unable to find a solution. The most varied and stupendous measures are being attempted in all the countries concerned, notably in the U.S.A., with varying degrees of success, and there is evidently no royal road to the solution of this most baffling problem. The resources of science have come in for some blame at the hands of certain people who contend that science has been responsible for all this unwanted abundance and therefore the depression and the suffering. It is good to hear this testimony to the value of science in increasing production, and we shall welcome that part of their view, but it is the height of unwisdom, I think, to attribute this world crisis even partially

to the resources of science. It is surely not the fault of science that world economics have been so worked that the abundance science has created is prevented from reaching the millions of ill-fed and ill-clad sections of mankind ; whoever has dammed up this plenty on one side while the hungry clamour for it on the other, it certainly is not science. For it is plain downright bedrock truth that as long as millions of people on this earth able and willing to work have yet to go without a proper measure of the primary needs of existence, there *cannot* be over-production or superfluity. To us in India, however, such a discussion can be of very little interest. The need in our agriculture is the help of science ; to bring down the cost of production, to reduce the vagaries of the season and dodge the droughts, to increase the yields, to reduce crop losses due to pests and diseases, to ensure quality in the marketable form of produce, to enhance the money return to the grower by furnishing industrial outlets for both his main produce and bye products, and to help to secure for his produce the best price possible, in all these the help of science is an urgent need and science must come to our rescue.

I have briefly indicated the nature of the work that has been accomplished so far, and have drawn attention to some promising lines of work. We have, however, touched only the fringe of our sphere of usefulness, for this is practically unlimited. I have said enough to show that the Indian ryot has admirably responded to our efforts and that he is not the ignorant, over-conservative individual who is so wedded to his old practices that he will not change. This should put heart into all of us and spur us on to still greater efforts and achievements.

Section of Agriculture.

Abstracts.

STATISTICAL STUDIES IN AGRICULTURAL EXPERIMENTS.

1. Sampling error in irrigated soils.

M. A. SHAMA IYENGAR *and* R. V. TAMHANE, Sakrand, Sind.

For purposes of analysis, representative samples of soil were being obtained as follows :—

Samples were drawn from five spots—four about the corners and one from the centre of each experimental plot and then the soils from the respective layers were mixed together to give a single composite sample.

But the statistician did not approve of the procedure and recommended instead the analysing of the samples from the five or more spots separately to yield an average figure. This being both expensive and time-consuming, work was undertaken to determine if such separate analysis was necessary under irrigation conditions.

Intensive samplings from both irrigated and virgin salt lands were made at short and equal distances of four feet, and the samples analysed both separately and in combinations for the salt percent. The data was subjected to critical statistical analysis.

The results show (1) that such separate analysis is unnecessary and (2) that for an experimental plot 1-40th acre a composite sample obtained by sampling and mixing soil from four random spots—one per quadrant—adequately represents the real state of affairs in the soil.

2. Some complex experiments on rice.

S. K. MITRA *and* P. M. GANGULI, Assam.

A series of experiments were taken up in 1934 at the Rice Experiment Station, Karimganj (Assam), with two factors, such as (1) spacing and number of seedlings, (2) varieties and age of seedlings, and (3) varieties and time of transplanting, to find out the results of combining two factors in the same field. They were laid out in randomised blocks and Fisher's methods of analysis of variance were used in calculating the results. Significant results were obtained in a few cases while the rest were negative.

The results obtained were not only more efficient in the point of supplying simultaneous replies to two sets of questions but were also capable of throwing light on the differential response of the two treatments which could not be done in any other way. A complex cultural experiment with four factors, including most of the above, has been taken up in 1935.

3. Methods of confounding and analysis in agricultural experiments, with examples.

M. VAIDYANATHAN, New Delhi.

4. On the estimate of missing yields in a split-plot type of arrangement.

S. S. Bose *and* P. C. Mahalanobis, Calcutta.

With increasing complexity of modern agricultural experiments, it is now necessary, for facilitating agricultural operations, to arrange the field with suitable restrictions—that is, to use the split-plot type of field design. For such designs it is necessary to calculate two or more residual errors adequate for testing the significance of whole-plot and sub-plot treatments. If one or more plots are missing in such an arrangement, Yates' formula for calculating missing plot (which was developed for perfectly randomised arrangements of Randomised Block and Latin Square type) is not suitable. In this paper a method has been worked out for estimating the missing yields in the case of a split-plot type of arrangement.

5. On the estimate of mixed up yields in an agricultural field experiment.

S. S. Bose *and* P. C. Mahalanobis, Calcutta.

F. Yates has shown that a valid estimate of error can be obtained in the case of randomised blocks and Latin squares if the missing yields are calculated by minimising the error variance and the degrees of freedom corresponding to the residual variance are properly allowed for. This principle has been found to be adequate for estimating the individual yield in the case of two or more plots whose yields have been mixed up. The formula is very simple and can be easily worked out. Thus with two mixed up plots and f-fold orthogonal classification, the yields of the individual plots are given by

$$x = Z \pm \frac{a(A_1 - A_2) + b(B_1 - B_2) + \ldots\ldots f(F_1 - F_2)}{2(N - a - b - \ldots f)}$$

where Z is the total mixed up yield of the two plots, A_1, A_2, . . . etc., the sums of yields of rows, columns, treatments etc. consisting the mixed up plots and a, b, c, d . . . . f number of plots in each class. With more than two missing plots, the estimates may be obtained by the method of iteration. With estimated values, however, the method of testing significance is slightly different.

6. Importance of complex designs in agronomical experiments.

S. Shamsher Singh, Bikaner State *and* P. M. Kulkarni, Indore.

Agronomic investigations aim at rapid improvement of cropping practice. Pointers can be quickly obtained and followed with precision if field experiments are designed to compare simultaneously wide variations in intensities of vital environmental factors, both singly and together. Factors considered essential are (1) atmospheric temperatures and humidities, (2) soil moisture-supply, (3) nutrition, and (4) available root-range. This was illustrated at the Bikaner State Farm, Sriganganagar, where neither irrigations nor spacings compared separately showed differences ; only sowing dates did so. When studied together in the same experiment, clearly defined results emerged.

Sowing date: Yield-superiority of *June-sown* Mollisoni cotton disappeared with heavy irrigation and manuring with nicifos 22·18.

Irrigation : May-sown Mollisoni wide spaced with castor cake yielded better with *moderate irrigation* than *heavy* instead of being equal. Closely

spaced June-sown P. 289F with nicifos yielded better *moderately irrigated*, but when May-sown and cake-dressed yielded better *heavily irrigated*.

Spacing: *Widely-spaced*, June-sown Mollisoni with cake yielded better with moderate irrigation than when *closely spaced*, but under heavy irrigation the difference vanished. May-sown P. 289F, *closely spaced*, heavily irrigated and manured with nicifos, yielded higher than when *widely spaced*.

AGRICULTURAL CHEMISTRY AND MICROBIOLOGY.

7. Potash fixation in soils.

DALIP SINGH *and* INDERSAIN SIKKA, Lyallpur.

In view of the fact that all the potash added to the soil in an available form does not remain there as such, experiments were designed with a view to determine the availability of different artificial potassic manures, as well as molasses, on two types of Lyallpur soils. As the result of these experiments carried out in triplicate, it was observed that after some months all the potash added to the soil in the form of sulphate, chloride and nitrate does not remain in an available form, but some of it changes into a non-available form. The potash that is rendered non-available is greater in the case of sulphate than in the case of nitrate or chloride. On the other hand, where molasses alone was used, not only all the available potash present in the molasses, but also a certain quantity which previously existed in the soil in a non-available form, has also been rendered available. Lastly in experiments where molasses and artificials were used simultaneously, the availability of potash is more than where artificials alone have been employed, but less than where molasses alone was used.

On the basis of these experiments the use of molasses as a potassic manure on sugarcane fields is recommended.

8. Comparative study of regional soils.

L. N. DESAI *and* S. C. CHAKRABARTY, Indore.

Cambodia cotton grows well in Jaipur and Badnawar (Dhar State), but completely fails on unaltered black cotton soils. Similarities between Jaipur and Badnawar soil profiles and differences from Indore black soil profile were found in the distribution of coarser fraction, hygroscopic moisture and total nitrogen content. In the surface zones the percentage of available phosphates on total was least and that of available potash greatest in the Jaipur soil. This position was reversed in Indore soils. More than 75 per cent. of the available phosphates was in organic form, and this was highest in the surface horizon of the Jaipur profile and lowest in Indore. The ratios of organic to inorganic phosphates varied similarly. In Jaipur and Badnawar soils much more potash was available than in Indore soils in proportion to nitrogen and also to available phosphates, both organic and inorganic. The probable significances of these are discussed.

9. The influence of treatment and the cotton crop on the soil profile.

S. C. CHAKRABARTY *and* L. N. DESAI, Indore.

Profiles of black cotton soil, untreated and treated with heated soil, with or without farmyard manure, were examined after the harvest of Malvi and Cambodia cotton. Hygroscopic moisture was reduced in the upper layer by heated soil, manure and by the growth of Cambodia.

The distribution of nitrogen was affected by the several factors and by the magnitude of the yield obtained. Differences were also observed in base-exchange capacity, carbon content, C-N ratio and the percentage increase in the conductivity of soil-water after thirty days compared with that after one day's immersion.

10. The biological oxidation of elemental sulphur a possible means of reclaiming alkali soils.

K. R. NARAYANA IYER, Travancore.

There are large areas of alkali soils in South Travancore lying more or less in a barren condition at present. The non-productivity of these soils is chiefly due to the comparatively large quantities of sodium carbonate and sodium bicarbonate. The soil of the area is heavy clay but contains a fair amount of lime in it. A crop of paddy is generally raised on these soils under perennial irrigation. Owing to the deleterious effects of the alkali salts the crop fails in patches and the yield obtained is extremely low, oftentimes being next to nothing. Experiments conducted both in the laboratory and on a small scale in the field on the possibility of reclaiming these soils by the application of elemental sulphur have given very encouraging results. The crop yields obtained from the sulphur-treated plots show an increase of about 150 per cent. over the untreated ones.

11. Decomposition of molasses in soil.

T. J. MIRCHANDANI *and* P. K. ROY, Sabour.

The study of the decomposition of the molasses in soil, under ærobic and unærobic conditions, has been made in the laboratory at Sabour. The sugars, which amounted to over 30% of the dry sample, disappeared almost completely in less than three weeks. The production of available nitrogen was found to be too small to be beneficial to crops. The addition of oxidising agents hastened the decomposition of the material. Evidence has been secured of the fixation of nitrogen in soil as a result of incorporation of molasses in it.

The molasses from carbonitation factories was found to be richer in nitrogen than that from the sulphitation factories, but there was little difference in the potash content.

12. Sunlight and nitrification in soil.

N. V. JOSHI *and* S. C. BISWAS, Pusa.

Experiments were carried out to test the theory of Dr. Dhar and his colleagues about (1) the photochemical production of ammonia and (2) also the photo-oxidation of ammonia to nitrates in pyrex glass flasks as well as Quartz silica vessels and also by exposing the soil direct, without any glass cover intervening between the soil and the sunlight or the ultra-violet rays.

Indications of ammonification or nitrification by the photochemical activity of the sunlight were not observed in any of the experiments.

Exposure of the soils and solutions containing ammonium salts to ultra-violet rays gave no indication of oxidation of ammonium salts.

Slight amounts of nitrites were observed after the first few hours of exposure to ultra-violet rays but even this quantity was found to have decreased after further exposure.

Reduction of nitrates initially present in the soil was observed when the soil was exposed to sunlight or ultra-violet rays. Nitrates added to the soil were similarly reduced.

In these circumstances it is doubtful whether the nitrites observed in the soil by supporters of the photochemical processes of formation

nitrates in soil should be designated oxidation of ammonia. According to our experiments the nitrites are probably derived from the reduction of nitrates in the soil.

AGRICULTURAL METEOROLOGY.

13. On the micro-climates of different crops.

L. A. RAMDAS, R. J. KALAMKAR, *and* K. M. GADRE, Poona.

Recent work has shown that the micro-climates of different crops differ from each other as well as from that of the open. The magnitude of these variations, their diurnal variation, etc., are discussed in the case of a number of crops.

14. Precision observations on rice at Karjat.

R. J. KALAMKAR, Poona.

Precision observations on the development of rice were taken at Karjat according to the 'Precision Scheme' drawn up in the Agricultural Meteorology Branch at Poona. The observations were recorded in 1934 and 1935 with the co-operation of Mr. Kadam, the Crop Botanist. The data have been analysed and are discussed in the present paper.

15. The moisture variation index of different types of soils in India.

L. A. RAMDAS *and* M. S. KATTI, Poona.

The hourly variations in the moisture content of different soils when exposed to the atmosphere during the clear seasons at Poona have been measured. These data show that each type of soil has a characteristic diurnal variation. All soils have their minimum moisture content at the epoch of 'maximum air temperature', and their maximum moisture content at the epoch of 'minimum air temperature'. The diurnal variation in the case of the soil at Poona is observed to decrease very rapidly with depth, being negligible at a depth of one or two inches.

16. The variation of soil temperatures under different covers.

R. K. DRAVID, Poona.

The effect of covering the local soil with thin layers of representative soils from different parts of India has been studied at the Central Agricultural Meteorological Observatory at Poona by recording comparative observations of soil temperatures during the clear season. Similar observations have also been taken in a plot having a short crop of vegetation. These data are discussed.

17. On the physical properties of some representative soils in India.

M. S. KATTI, Poona.

Measurements of the times taken for completely drying different soils, their heats of wetting, and other physical properties like specific gravity, specific heat, etc., have been made. These data are discussed in relation to the moisture variation indices of the different soils.

18. The effect of rainfall on the yield of cotton at the Government farm at Akola.

R. J. Kalamkar *and* V. Satakopan, Poona.

The effect on yield of rainfall in the season consisting of thirty-one periods, each of five days, from 22nd May to 23rd October is investigated. The rainfall response curve is obtained by using Fisher's well-known method. The data extend over a period of 28 years commencing from 1908. The curve showing the response to an additional inch of rain indicates an adverse effect of rain in the third week of May, a beneficial effect in June, and an adverse effect in July, August and the early part of October.

19. The analysis of yields of crops at the Government experimental farms in the Central Provinces and in the Bombay Presidency.

R. J. Kalamkar, Poona.

The yield data for some of the important crops at six centres in the Central Provinces and seven centres in the Bombay Presidency extend over periods varying from 10 to 26 years. Interesting information is obtained as regards the response of the same variety grown at different centres and different varieties grown at the same centre. These results are discussed.

20. On secular trends in rainfall statistics.

N. Rajagopalan, Poona.

The secular variations in the rainfall data of the Kadur and Shimoga districts in the Mysore State, Belgaum district in the Bombay Presidency and Rangoon in Burma have been studied. The significance of these trends is discussed.

21. On the correlation between the rainfalls during the South-West monsoon at raingauge stations in the Amraoti district in Berar.

N. Rajagopalan, Poona.

Comtemporary rainfall correlations have been worked out for the different raingauge stations in the Amraoti district in Berar with a view to examine the homogeneity of this area in studying crop-weather relationships.

22. Micro-climatology of an irrigated cotton field in Sind.

B. M. Dabral *and* S. S. Chiney, Sakrand (Sind).

MANURES AND MANURING.

23. Green manuring for sugarcane in the United Provinces.

R. L. Sethi, Shahjahanpur.

With a view to exploring the possibilities of using *Crotolaria juncea* (*Sanai*) as a green-manuring crop for manuring the extensively cultivated crop of sugarcane, experiments were conducted for about six years at the Sugarcane Research Farm, Shahjahanpur, and it was found that it fitted

in well with the prevailing practices of the cultivators and afforded a cheap and simple method of raising the fertility of the soil. If carried out under favourable conditions it increased the yield of the sugarcane crop easily by about thirty per cent. The data is statistically interpreted. The method of growing *Sanai*, ploughing it in the soil, and limitations with regard to times of sowing, harvesting and watering are fully explained. Costs with other nitrogenous manures are also compared. It was also found out that a good crop of *Sanai* supplied approximately about 200 maunds of green matter, between 50 to 55 maunds of dry organic matter to the soil, and accumulated about 60 lbs. of nitrogen per acre for the use of the succeeding crop of sugarcane.. The yield of the cane was closely connected with the accumulation of nitrate in the soil in the early of growth, i.e. from April to June, and that any deficiency in available nitrogen at that period could not be compensated for at later stages.

24. The response of rice plants to successively higher doses of nitrogen.

K. C. Banerji, S. S. Bose, *and* P. C. Mahalanobis, Calcutta.

Nine successively higher doses of nitrogen were applied to a series of pots growing rice plants belonging two varieties : *Jhingasail* and *Bhasamanik*. There were three replications of each variety. The length of the plants and the tiller number were recorded throughout the life-period of the plants. The number of fertile and sterile spikelets as well as the weight of grain and straw for each individual plant were noted. The Z-test showed the significant effect of the doses of manures for each of the characters noted above. The increase began to be appreciable from the third dose and did not reach the limiting value even up to the biggest dose of the experiment.

25. Humus supply to irrigated arid soils.

S. Shamsher Singh *and* P. M. Kulkarni, Indore.

This investigation was intended to find a suitable method of increasing yields of toria, wheat and cotton in the local rotation by utilizing the vacant period before the rabi crop for increasing soil humus. Uncropped fallow before toria gave higher yields than when guara or sann was ploughed in. Addition of compost had no effect. Ploughing in the green manures was better than removing them. The succeeding cotton crop gave higher yields with green manures ploughed in than with fallow.

Another experiment showed no depression of toria yield when green manure was ploughed in after two months' growth and compost added, showing a way to secure larger cotton crops without lowering toria yields.

With the wheat crop green manure was beneficial, but compost only after fallow.

26. Soil texture, nutrition and staple-length of cotton.

S. B. Mogre *and* Y. D. Wad, Indore.

Mean staple-lengths of pooled pickings of Malvi and Cambodia cotton changed by treating black cotton soil with compost, acid, nitrogen, potash and phosphate, alone or together, in a quantitative pot test in 1934.

The same maximum was obtained (23·4 to 24·9 m.m.) in:

1. Both varieties with nitrogen plus compost plus acid.
2. Malvi: with or without nitrogen in untreated soil, and with nitrogen and potash or nitrogen and phosphate in acid-treated soil.

3. Cambodia: with compost plus phosphate or potash, and in the absence of compost, by nitrogen plus potash or, with acid, by compost plus phosphate or compost plus nitrogen plus phosphate.

Cambodia with compost and potash gave the highest yield and staple-length, but with Malvi the highest yield did not coincide with the longest lint, though nitrogen plus compost was good in both respects.

Compost increased and nitrogen decreased staple-length of Cambodia, in Malvi it was decreased by compost but unaffected by nitrogen.

Potash and phosphate reduced lint length but this effect was modified by nitrogen, texture differences and varieties.

Determinations of swollen-hair diameter on these samples are being made to find the best environment for well-developed, and therefore strong fibre, with high yields.

27. Manuring of cotton for yield in Malwa.

C. K. CHHAYA *and* P. M. KULKARNI, Indore.

Indications derived from results of pot-cultures were put to test at Indore in a six-factor field trial with Malvi cotton on rich soil and at Dhar in two four-factor trials with Malvi and Cambodia on poor soils. 40 per cent. higher yields were obtained at Indore at a cost of Rs. 3-2 and Rs. 4-3 per acre with Nicifos 22-18 and safflower cake respectively for all spacings, methods of interculture and manuring tested.

At Dhar Nicifos 22-18 had no effect on the yield of Malvi. Safflower cake depressed yields of Malvi and increased those of Cambodia.

28. Cotton yields as affected by soil condition and nutrients.

S. B. MOGRE *and* G. T. SHAHANE, Indore.

In contrast with the previous inconclusive field tests of humic manures, the yields of both American Cambodia, Indore 1 strain and Desi (Malvi 9) cottons were greatly increased by manuring in the soil profile.

Following this clue pot tests were made in 1933 to find the nutrients giving the greatest increase of yield for each variety.

This was followed in 1934 by tests to find the soil conditions under which such nutrients were most efficiently utilized. Both the varieties yielded best with nitrogen applied in two doses and nitrogen plus phosphate in one dose.

Improvement of soil condition by compost led to better use of nitrogen by both varieties but when phosphate was added this held good only for Cambodia. Malvi used these nutrients best without the change in soil condition due to compost.

29. Initial start to cotton seedlings and the nature of soil and nutrition.

I. MADHUSUDANRAO *and* C. L. NAGAR, Indore.

Previous experiments have proved that increase or decrease in cotton yields is chiefly determined by the favourable or unfavourable soil conditions in the early stages. Pot-culture studies are described on the influence on dry weight production of leaves, stem and total of *desi* and American cotton during the first 42 days of profile horizons from rich, medium and poor fields of black cotton soil, with and without compost and artificials, singly and together on *desi* and American varieties. For both the varieties, the difference between the maximum and minimum values of dry weights were far greater with manured soils than those untreated. The combined effect of compost and artificials gave the highest weight for leaves and stems on soils of upper and lower horizons in all fields with Cambodia cotton. The relative influence of compost and

artificials changed with the fertility of fields, the horizons and the varieties. Artificials when alone gave the maximum production only in the top layer of medium soil.

CROPS AND CROPPING METHODS.

30. Groundnut—its cultivation in Malwa.

G. C. TAMBE *and* S. C. TALESARA, Indore.

Groundnut had been suggested for Malwa by Moreland in 1914 and by Howard in 1920 as a cash crop likely to increase soil nitrogen at Indore. Since 1932 this crop has been studied as regards (1) agricultural possibilities, and (2) production costs.

Out of the three promising varieties, Gangapuri was the best yielder, both for nuts and fodder; Akola 10 came next. Soil fertility alone controlled yields of varieties. Farm compost dressings, variation in seed-rate and spacing or the depth of interculture did not show any influence during very wet seasons. Environment influenced the oil content and the shelling percentage of Gangapuri the most and of Spanish peanut the least. A possibility of reducing the cost of shelling seed for sowing was discovered from the results of three germination tests. According to conditions shell-cracked and soaked nuts germinated as well as, or better than, shelled kernels.

The suitability of varieties is discussed on the basis of their agricultural behaviour, yield of oil and palatability and differences in production costs.

31. Cultivation of high quality paddy in unpuddled black cotton soils.

C. L. NAGAR, T. KRISHNAMOORTHI, *and* P. M. KULKARNI, Indore.

High quality varieties of paddy from different parts of India have been grown successfully as a rains-crop for four years on black cotton soil without puddling or irrigation, soil management and growing season being adjusted to the requirements of the crop. A quantitative experiment was made in 1934 upon two varieties, with two planting seasons, humic and chemical manures.

Grain: Transplanting soon after the onset of rains was superior to the later planting at the usual time. The scented Mushkan yielded better (739 lbs. per acre) than the fine Pahan (585 lbs. per acre) when planted early, but the order was reversed by late planting. The crop responded best to Municipal compost and to Nicifos grades, yields of early plantings increasing thrice and twice respectively. A fifty per cent. increase followed a double dressing of Municipal compost (40 cartloads per acre) and a treble dose of Nicifos (3 cwts. per acre), Mushkan responding better than Pahan, and early planting more than late.

Bhusa: Yields were similarly affected by treatments as those of grain except in a few cases with Nicifos grades. After harvest in early October a good wheat crop was grown. A valuable cash crop is thus made available for black soil tracts with a rainfall of at least 30 inches. Further adjustments are in progress.

32. Bajra (*Pennisetum typhoideum*) and tur (*Cajanus indicus*) in Jaipur State.

K. R. JOSHI *and* P. M. KULKARNI, Indore.

Bajra, the *Kharif* cereal crop of Jaipur, has been studied since 1932. The possibilities of (1) securing supplies of silage cheaply and conveniently,

and (2) the introduction of early Malvi Tur (which escapes frost) as a sub-crop by spacing adjustments were tested.

The row-spacing of 8 ins. for *bajra* gave maximum yield of fodder, but was less profitable than *bajra* and tur with a spacing of 15 ins. or 21 ins. grown alone or in association. A mixed crop of four rows of *bajra* and two of *tur* was found suitable both for income and supply of grain and fodder. The spacing could be increased from 12 ins. to 20 ins. without affecting the acre-yields and with a chance of increasing them in favourable years.

Good silage can be made from bajra stalks after harvesting the ears immediately they are ripe enough.

33. Sugar beet: A possible cash crop for Central India and Rajputana.

I. MADHUSUDAN RAO *and* S. GHOSH, Indore.

Sugar beet was found to grow well as an autumn crop on the black cotton soils in Central India and on the soils of Rajputana, and resists frosts. Under local conditions the cost of cultivation and watering is far less per ton of sugar produced in the crop than in sugar-cane. Very high sugar contents are obtained and yields are normal on black soils and abnormally high in Rajputana. It can be easily sliced and dried in the sun, and then stores well. It has responded very well to manures. It can ripen within five months after sowing and yields have increased by keeping it in the soil till April or May.

Soil conditions being favourable it can be grown as a kharif crop when it ripens in October with maximum sugar percentage. This then falls, rises again in February to its maximum and remains steady till May.

34. The possibilities of soyabeans in Central India.

R. K. AURANGABADKAR *and* B. GOSWAMI, Indore.

Hopeful results from previous trials led to a comparison of thirty varieties from the United States, of the yields of seed, plant weights, sizes and habit, period of maturity, oil- and nitrogen-contents of seed with their soaking and cooking qualities and edibility. The kharif season suited the crop best and it grew well when intersown with cotton and groundnut. A possibility of its introduction without disturbing the local rotation of crops is thus indicated.

The technique used for soaking and cooking tests was also applied to tur (cajanus indicus) and gram. The conclusions from these tests were found to agree well with the bazaar assessment of quality.

35. Cambodia cotton in Jaipur.

K. R. JOSHI *and* G. K. SANT, Indore.

Cambodia (Indore I strain) was found to grow satisfactorily in the well-irrigated areas in Jaipur State. Since 1932 agricultural conditions best suited to the crop have been and are being investigated. Starting the crop before the rains usually gave better yields than sowing on the rains. Spacings did not affect the yields. With equal spacing, Castor cake (at 21 lbs. of Nitrogen per acre) was consistently superior to Nicifos 17/45 at the same rate, which did not differ from control, indicating the apparent necessity of application in several doses if inorganic manures are used. With each earlier sowing date, the yields for each treatment increased, the rate of increase being more marked with cake-manuring.

In general, cake-manuring gave fairly uniform and normal values for giving percentage with all the treatments.

The figures for control and Nicifos-manured plots fluctuated around 30%.

36. Tobacco curing for bright leaf : simple adjustments.

S. B. MOGRE *and* G. T. SHAHANE, Indore.

The agricultural possibility of growing bright cigarette tobacco in Central India and Rajputana having been proved, the demand arose from cultivators for a simple and cheap method of curing.

In a normally developed and mature leaf, existing data showed that the only essentials were even ripening ('yellowing') and drying the contents intact.

Maintenance of suitable moisture and warmth inside the leaf, by controlling the effect of weather fluctuations, seemed to be enough to develop and fix the leaf colour in a rainless curing season, without rigid observation of humidity and temperature scales as in flue curing.

Dry grass was found to protect the leaf adequately from deterioration during yellowing and drying. The large-scale practicability of the modification that proved to be statistically superior was finally established.

When the leaves were suitably grouped and separately spread between layers of grass during yellowing and fixing stages respectively, the mean percentage of properly yellowed leaves was 80 and that of such leaves when fixed was 52.

About a thousand bundles (12 maunds) of dry grass were required per acre of tobacco, and could again be used for feeding cattle.

Tobacco experts reported favourably on the cured samples thus prepared. The same principles have been applied to raise the quality and uniformity in grade of Zarda and Hukka types.

By adjustments in fermentation to destroy undesirable components, young shoots and unripened leaves obtained from primings and suckerings have been converted into high quality trash similar to that from broken mature leaf.

37. Efficient tobacco seed production.

S. B. MOGRE *and* V. N. BHARGAVE, Indore.

Agriculturally the large-scale cultivation of all types of tobacco, and especially bright leaf, has shown good prospects in Central India and Rajputana during the last three years.

The yield and quality of the crop is known to be influenced by the quality of the seed, hence the normal agricultural factors likely to affect this were studied.

A simple technique is described for separating trash and light seed by winnowing and sifting to collect a uniform, heavy seed.

A high percentage production of heavy seed can be obtained from (1) seed plants and from ratoons after frost damage, (2) from plants with a low or high seed yield, and (3) during winter or summer months.

Obviously this depends upon the result of interaction of several factors and not upon the intensity of one factor.

In un-irrigated fields bright types of tobacco give higher proportion of heavy seed than the heavy dark types ; under irrigation the proportion is less.

Under favourable conditions the yield of heavy seed may be increased by suitable manuring, and it is not adversely affected if all the leaves are allowed to mature on the plant.

38. Varieties of pepper cultivated in Travancore.

N. K. B. KURUPP, Travancore.

In this paper are given in full detail descriptions of eighteen different distinct varieties of pepper cultivated in Travancore. These varieties consist of :—

(1) Kumbhakodi, (2) Balamkotta, (3) Chumala, (4) Perumkodi, (5) Karunthakara, (6) Karuvally, (7) Karuvilanchy, (8) Arikottanadan, (9) Kalluvally, (10) Kaniyakadan (large), (11) Kaniyakadan (small), (12) Kottanadan, (13) Munda, (14) Thulakodi, (15) Mundi, (16) Kuthiravali, (17) Wild pepper (large), and (18) Wild pepper (small).

These are well illustrated by photographs. Graphic representations showing the periodic variations in the prices of pepper in the State are given in the paper. A statement showing the rainfall obtained in different places in Travancore is also included with a view to study the effect of rainfall on pepper cultivation.

39. Preparatory cultivation for wheat in Malwa.

G. C. TAMBE, S. C. TALESARA, *and* L. SWAROOP, Indore.

The Malwi cultivator usually leaves his land without weeding and cultivation to the end of the rains, then bakhars it twice or thrice and sows wheat at the end of October. The soundness of this practice and possible scope for improvement have been investigated. Clean monsoon fallow followed by different depths of cultivation at the end of rains, with and without interculture of the subsequent wheat crop, did not produce yield differences. Allowing weeds to grow in the fields in the rains, with their subsequent removal or otherwise, had no influence on yields. Ploughing in early October after a catch-crop of un-puddled rice followed by a few *bakharings* gave nearly twice the yield of wheat, when ploughing was done seventeen days later, irrespective of the date of the rice harvest.

40. Cold weather cultivation of vacant fields and interculture of standing crops in Malwa.

G. C. TAMBE *and* S. C. TALESARA, Indore.

Deep cultivation, soil inversion and interculture to produce a deep mulch have often been beneficial to crop growth in many countries. The possible advantages of the introduction of such methods have been investigated at Indore since 1932. A continuous experiment on cold-weather cultivation running three years revealed no favourable influence on the succeeding jowar, groundnut, cowpea, wheat and cotton. A three-years' continuous trial for kharif crops and seven single-season tests—6 for the kharif and 1 for the rabi—have been carried out since 1932, to test the usefulness of interculture, deep or shallow. Deep interculture was sometimes harmful, the effect of shallow interculture as locally practised, when favourable, were found to be due to weed removal rather than to the mulch produced.

41. A complex cultural experiment with rice at Chinsurah, Bengal, for the year 1934-35.

S. C. CHAKRAVERTTI, S. S. BOSE, *and* P. C. MAHALANOBIS, Calcutta.

The data of the second year of an investigation on the cultural experiment on rice have been analysed in this paper and the results have been compared with those of the previous year. The three varieties under test maintained their relative position with regard to yield, but the mutual differences were not proportional in the two seasons. August 1st was found, as in the last year, to be the optimum date of transplanting. Variation in spacing and seedling numbers were practically without any effect, and a very satisfactory distribution of rainfall gave a very heavy yield which often masked the responses due to many of the cultural treatments.

42. The influence of the date of planting and the number of seedlings per hole on tillering in rice at Bankura.

K. C. BANERJI, S. S. BOSE, *and* P. C. MAHALANOBIS, Calcutta.

A complex cultural experiment was laid out in the Government Agricultural Farm, Bankura, to determine the effect of the date of transplanting and the number of seedlings per hole on the yield of rice. There were five dates beginning from August 15 to October 14 at intervals of three weeks and 5 seedling numbers: 1, 2, 3, 4 and 5 respectively. The number of tillers in each plot of 100 plants was counted, and the analysis showed that if the age of seedling at transplanting is kept constant, the later transplanting produced more tillers than the earlier ones, and that tillering increased steadily as the number of seedlings increased from 1 to 5. There was no evidence of an interaction between date of planting and seedling number so far as tillering in rice was concerned.

43. A situation experiment with rice.

K. C. BANERJI, S. S. BOSE, *and* P. C. MAHALANOBIS, Calcutta.

The rice fields in Western Bengal mostly occur in terraces, and cultivators generally recognise, according to the elevation of the field, four types of land namely *Dāngā*, *Bād*, *Kānāli* and *Shole* which are suitable for *Aus*, early *Aman*, inter *Aman* and late *Aman* respectively. Eight varieties, suitable for different situations, were grown together in three of the above types of land in four replications with a view to studying the relative efficiency of each variety in the different situations. Observations on the height of plant, tiller number, fertile and sterile spikelets, weight of grain and straw, length and breadth of grain were taken and analysed by Fisher's method of analysis of variance. The results show that the rice varieties have a wide range of adaptability, and that the situations do not exhibit appreciably different interactions for the various types of rice selected for the experiment.

PLANT PATHOLOGY.

44. Root-study of susceptible and resistant cotton to root-rot in Gujerat.

A. F. PATEL, Baroda.

No. 8, which is a selection from Broach 9, was found more resistant to Root-rot, whereas Broach 9 is known to be extremely susceptible. The study of the roots of these showed significant differences in length and thickness of tap roots and in length of thick laterals of lower regions.

45. Physiological studies on the Gujerat cotton root-rot organisms.

G. H. DESAI *and* V. N. LIKHITE, Baroda.

The organisms connected with the Cotton Root-rot in Gujerat have been fixed as *Macrophomina phaseoli* and the *Cephalobus* sp. of nemas. Studies in their physiological characters show that both these are alkali-loving and thrive well in alkali media. This leads to the use of acid manures for the check of the disease.

ENTOMOLOGY.

46. Some problems connected with the stem-borer pest (*Schoenobius incertellus*, W.) of rice in South India.*

T. V. RAMAKRISHNA AYYAR *and* K. P. ANANTHANARAYANAN, Coimbatore.

Of the numerous insect pests in South India, which have attracted the attention of economic entomologists during the past two decades, the paddy stem-borer can claim not only to be one of the most important but also the earliest insect to come to some prominence. Being a well-known insect and enjoying a very wide distribution all along the tropics of S.E. Asia, the problems connected with this insect have been engaging the attention of workers for many years. In this paper an attempt is made to review briefly the work done so far and to add a summary of the results of the recent investigations made on the bionomics of this insect by the writers in S. India. In the absence of any connected account of this insect till now, it is believed this paper might also serve to some extent the purpose of helping future workers in S. India, to get an idea of what has been done till now, and what still remains to be done in this direction. The main headings under which the subject is treated include the previous records and studies on the pest in the province and the summary of more recent observations on the same. These include the general and local distribution of the insect; the systematic position, life-history, habits and natural enemies of the insect; the nature and extent of damage done to rice; the various factors so far known influencing the degree of infestation; and some remarks on the problem of control. One important object of the paper is to invite remarks and criticisms from workers on the same subject from other provinces where also the pest might be found distributed.

47. Bionomics of the swarming caterpillar of paddy in South India.

K. P. ANANTHANARAYANAN *and* T. V. RAMAKRISHNA IYER, Coimbatore.

It is well known that among the insects injurious to paddy in S. India, the swarming caterpillar (*Spodotera mauritia*, Boisd) is practically the most destructive, causing very serious damage to the young crop almost every year in one or other of the various rice areas of the province. As a result of investigations during the past many years, a considerable amount of data has been collected on the bionomics of this notorious insect, and during the past two or three years some special attention has been devoted in this direction. It is the purpose of this paper to present a brief résumé of the work done previously and add a summary of the recent studies made on this insect by the writers, particularly in connection with the general features and habits of the caterpillar of this insect, which is really the destructive stage of it. The main aspects of the studies made in this connection include the following:—Previous work on the pest; geographical distribution; systematic position and general features of the adult moth; life cycle and habits of the caterpillar, in different stages in captivity and in the fields; influence of natural factors on the caterpillar; the status of the pest, and incidence especially in relation to Kole paddy; and possible lines of future work on the same. The writers feel that it will be interesting and helpful to them if any criticisms or remarks are offered in this paper by workers in this line in other provinces.

48. The white-ant pest on cotton in Sind, and its control.

B. M. Dabral *and* R. M. Ranji, Sakrand (Sind).

49. An outbreak of *Contheyla rotunda*—A limacodid pest on coconuts in Cochin.

C. S. Venkitasubban, Cochin.

The paper details the main features of a severe outbreak of *Contheyla rotunda*, a caterpillar of the Limacodid family of moths, which occurred during the hot months of the year 1933, in one of the suburbs of Cochin. More than 5,000 coconut trees situated along the ' Backwaters ' near the sea were badly affected. The characteristic damage is the scorching and drying up of almost all the fronds of the affected trees. The life-history of the pest, the cause of this outbreak, the combative measures adopted, and the conditions that led to the subsequent revival of the affected trees, are narrated in brief. The pest is a common insect in all gardens of the State, and is found in small numbers throughout the year. It is subject to various hymenopterous parasites, as well as a disease during the rains. These destructive agents ordinarily keep the pest under check, and only when their influence is relaxed, can the insects multiply as pests. In recent times, the pest has broken forth in a severe form only on two occasions—one in 1917 and the other in 1933, and these infestations took place in two widely different localities. The history of this outbreak emphasises the fact that in any study of a pest, the enemies it is subject to and the conditions in which they thrive, must claim the foremost attention of an Entomologist.

50. A noctuid caterpillar boring into tender coconuts at Cochin.

C. S. Venkitasubban, Cochin.

This is a short account of a noctuid caterpillar found boring into tender coconuts in the Government Farm at Cochin. The insect seem to be a new one, and has not been found recorded as a pest of coconuts. A general description of the moth, larva and pupæ has been given. The damage consists in the falling down of the nuts, due to the caterpillars boring into and feeding upon the soft matter inside. The fully grown caterpillar is stout and more than two inches long, and it attacks half-grown coconuts after the fashion of rats. The insect has hitherto been noted in small numbers only; but evidently it possesses latent possibilities of becoming a severe pest. A photograph showing all the stages except the egg is appended.

51. The soorai disease of paddy in South India and its causative agent (*Ripersia oryzæ*, Gr.).

T. V. Ramakrishna Ayyar, Coimbatore.

In some of the paddy areas of the Madras Presidency, especially in the wetland tracts of the Tanjore delta, growing rice plants are commonly found subject to the attacks of a disease locally known by such names as ' *Soorai* ', ' *Sensoorai* ', ' *Dumpategula* ', etc. The existence of this malady in any area is generally detected by the presence in the fields of isolated patches of stunted and sickly plants gradually turning yellowish and beginning to wither. On a closer examination most of the diseased plants reveal the presence of numerous smooth reddish insects attached to the stem under the covering leafsheaths; it is therefore presumed that the disease is due mainly to the activities of this sapsucking

bug. This insect is a mealybug and has been identified as a specific pest of rice under the name *Ripersia oryzæ* Gr.

In this paper it is proposed to give a general account of the nature and extent of this disease in South India, of the more important features in the life-history and habits of the causative agent, the mealybug, and point out the economic importance of this disease to the rice cultivator in South India.

52. Parasites found in association with the cotton stem weevil pest (*Pempheres affinis*, F.) in South India.

T. V. RAMAKRISHNA AYYAR *and* V. MARGABANDHU, Coimbatore.

It is now over sixteen years since the cotton stem weevil (*Pempheres affinis*, F.) began to attract some attention as a fairly important pest of the cotton plant in South India, and a paper on the general features and life-history of the insect was published by the senior author. Since then the pest, which was in the early years confined chiefly to the Cambodia variety of cotton, has been attacking other cottons and distributing itself fairly widely in the cotton areas of South India. As a consequence special attention has had to be paid to this insect along with the other important insects—the bollworms, and even legislation had to be introduced for these important pests. Side by side intensive studies with different aspects of the problem connected with the insect have been going on by a special staff appointed for this work by the Indian Central Cotton Committee, Bombay. The peculiar habits of this insect have made it rather difficult to tackle it by means of the ordinary mechanical or insecticidal methods of control, and it is found that the only possible ways of keeping the pest under check must mainly consist of prophylactic cultural means or breeding of resistant strains of cotton, or by trials in biological methods by the use of parasites and predators.

Speaking of biological control, it is needless to add that it is necessary to find out whether such enemies exist and what their bionomics are before any control measures in this direction are attempted. With a view to find out if the pest is subject to the attacks of such natural enemies, the authors have been carrying on some work. Past experience had so far shown that this insect, unlike some of our common pests, is not commonly subject to parasites or predators and till now attempts in this direction have only revealed the existence of three parasitic wasps in comparatively very small numbers associated with the developing stages of the weevil pest. These being the first definite records of the insect enemies of the cotton stem weevil, it is the authors' idea to present this fact in this short paper with the available notes gathered so far referring to these parasites. These latter include one fairly large reddish brown braconid and two small chalcid wasps; the braconid appears to be a species of the genus *Spabhius*; and of the chalcids one appears to be a species of *Olinx* (*Eulophid*) new to science, and the other a new species—*Pachyneuron* (*Pteromalid*). Further studies are being made, especially to find out the real status and inter-relations potentialities of these parasitic wasps.

53. Kole cultivation of rice in the Malabar Coast, with special reference to insect pests.

T. V. RAMAKRISHNA AYYAR *and* K. P. ANANTHANARAYANAN, Coimbatore.

The peculiar method of raising a crop of rice, known locally as *Kole cultivation*, appears to be a practice existing only along the Malabar coast, especially in the southern parts of the British District of Malabar and the Native State of Cochin, and as far as the writers are aware the practice has been in vogue in these tracts for several decades in the past. The choice of the land selected for this purpose and the special methods

employed in that connection reveal a considerable amount of ingenuity and skill on the part of the inhabitants of these localities in utilizing all available means of adding to their income. The areas utilized to grow paddy in this way are large freshwater lakes situated between the submontane areas of the Western Ghats on the east and the narrow belt of coastal land with the system of backwaters along the west. The preliminary operations consist in completely draining away the accumulated waters of these lakes into the backwaters and canals along the west, early in the year (Jan.-Feb.), by various devices such as pumps, Persian wheels, etc., and sowing the seed broadcast on the swampy fertile lake-beds. The crop, which is irrigated when necessary with the pumped waters retained in the network of canals maintained in the midst of these areas, grows to maturity in from 3 to 4 months, and is generally harvested before the S.-W. monsoons begin, after which the areas are flooded with the rain water and they become lakes as before. This summer crop under normal conditions yields a very remunerative out-turn within a short period, leaving a very good margin of profit to the cultivator much higher than what the rice grower gets from his ordinary paddy fields elsewhere. But in certain years, due to unexpected causes, especially heavy summer rains and floods in April or May before harvest, the crop becomes a complete failure in the whole area and the cultivator gets next to nothing. The Kole cultivator knows full well that this practice is attended with heavy risks and the word Kole in local parlance is often used to connote a chance trial or lottery in which the individual either gains considerably or loses heavily. The writers having had some opportunities of studying the different aspects of the Kole cultivation in connection with their investigations of some paddy insects in South Malabar, it is their idea to present a short general account of the outstanding features of this method of rice cultivations, with some remarks on the insects associated with the crop.

PLANT PHYSIOLOGY.

54. Root studies in boro or spring paddy.

S. Majid, Habiganj.

A modified improved method for studying the nature and disposition of fibrous rooted crops like paddy under artificial conditions is described. This consists in fixing the wire meshes at different levels to frames attached at corners to vertical supports. The frames with their supports are inserted into the receptacles in which the study is to be made. At washing, when the receptacles are removed and when the soil is washed out, the nature and disposition of roots at different levels are revealed and can be studied from all angles both qualitatively and quantitatively.

The study deals with the root development of Boro paddies of different ages, and its response to different classes of soils varying from light sandy to heavy clayey soils of the following proportions: (1) sand, (2) 3 sand : 1 clay, (3) 1 sand : 1 clay, (4) 1 sand : 3 clay, and (5) clay.

The gradual transition of root formation, both with reference to zonal distribution and to secondary flushing, together with its relation to soil texture is discussed, besides bringing out the extreme expression of concentrated and compacted root development where the proportion of clay and sand are 3 : 1.

55. Root-studies—their scope in agronomy. I. Kharif crops.

N. S. Apte, Indore.

Healthy and diseased cotton plants showed differences in root activity. Whether vigour differences of healthy plants were similarly reflected in roots was studied in a randomised replicated field test in 1933.

Pre-rain-sown Malvi and Cambodia cotton plant-weights (60 days old) were higher than when rain-sown. Pre-rain sowing increased monopodial weights at maturity for both varieties, total plant-weights being equal.

The upper nine inches always contained most of the total root length which was greater in rain-sown and two-months-old crops. For both sowings activity decreased and death-rate increased with age. Two months after sowing there was a comparatively greater death-rate than the rate of production of fresh roots, for both sowings of varieties. Thus the differences in yield and monopodial growth between the two sowings of these varieties failed to show a relation to the root-length-total, active or dead, or to the degree of compensation for death-rate by fresh production except that the total root lengths of rains-sown crop at the first and second stages were superior to corresponding lengths of the pre-rains-sown crop. The significance of these observations has been discussed.

56. Root studies—their scope in agronomy. II. Rabi Crops.

K. M. SIMLOTE *and* R. K. AURANGABADKAR, Indore.

In two field trials on local wheat in 1932-3 the yield influences of (1) cultivations, and (2) spacings were tested.

Tilth differed with cultivations but not yields or initial moisture in the second four-inches.

Different spacings gave equivalent grain per acre, but different straw-yields. Grain and straw yields per plant increased with spacing. Increased grain accompanied increased straw, but not always vice versa. Straw and grain always increased with tiller number.

Root development was examined in both experiments thus :—

(1) 0—6″ ; (2) 6″—15″ ; (3) 15″ and below.

In experiment 1 during the growing stage the total root length was least in the top zone and uniform below. The activity was greatest in the lowest zone and equal above. At grain formation total root length had increased both absolutely and with depth, though the activity had decreased being least in the middle and greatest below.

Interculture reduced upper activity, other cultivation had no effect.

In experiment 2 root length and activity, unaffected by spacing, increased with depth at maturity.

The significance is discussed of the occurrence of similar root development irrespective of plant performance.

57. Efficiency of light in plant development.

I. MADHUSUDAN RAO *and* S. GHOSH, Indore.

The same cotton varieties yielded similarly in fields with different periods and intensities of daylight. The influence of atmospheric temperatures and humidities and the medium of growth on the efficiency of light in plant development was therefore investigated in 1934 in pot-culture.

Desi and American cotton varieties were grown in sand and in black cotton soil with added nutrients supplying equal quantities of nitrogen, and exposed alternately to normal daylight and darkness or to daylight followed by electric light throughout the night during the growing stage. Temperature and humidity differences were secured by two sowing dates.

Light increased bud-production only when the medium of growth did not equally increase or greatly depress it. When more buds were produced more were shed but the percentage and rate of shedding varied differently. When exposed to artificial light, shedding started earlier or later according to other conditions.

The stimulating effect of light did not extend beyond bud-production and the yields were lowered.

For each environmental condition, there appeared to be an optimum shoot-length necessary for the development to maturity of the buds produced.

The three varieties used showed characteristic differences in all the types of activity mentioned above.

58. Seed quality and crop vigour.

R. K. AURANGABADKAR *and* B. GOSWAMI, Indore.

Association was observed between the differences in yields and oil contents of groundnuts grown in different localities. Each crop could be sorted into groups of nuts differing in appearance, and the kernels from each group into different grades. The proportions of these groups and grades varied according to the crop-yield. Each grade of kernels differed in oil content. Field tests showed the persistence of such differences in the succeeding crop grown from each grade of kernel. Varietal habit and field fertility greatly modified the behaviour of grades. The probable nature and cause of these differences and their practical significance are discussed.

59. Optimum number of buds for sugarcane setts.

G. C. TAMBE *and* S. C. TALESARA, Indore.

The germination obtained by planting sugarcane setts with three eye-buds each, as is usual in Malwa, seemed to fall far below expectation. In March 1935 the influence on germination of the number of eye-buds was therefore studied. The results of a test replicated twelve times comparing the germination of setts with one, two and three eye-buds gave 14·4, 28·8 and 27·8 per cent. germination respectively. The odds in favour of the difference were 19 : 1, the significant difference being 8. It is clear that planting setts with two or three eye-buds makes no difference in germination, but it is reduced by half with single-bud setts. In another replicated test with ten-feet rows, single-bud setts previously soaked in lime water germinated as well as three-bud setts so treated and much better than any setts untreated.

60. Treatment to improve germination of sugarcane setts.

G. C. TAMBE *and* S. C. TALESARA, Indore.

Three-bud setts of sugarcane Co. 290 soaked in lime-water overnight, were planted in alternate rows along with freshly cut unsoaked setts at the end of February 1935. The mean number of shoots counted 47 days after planting per 100 setts treated and untreated was 125 and 61 respectively, with a significant difference of 15.

The lime-treatment gave numerically higher values for degrees—Brix taken in October and November, but the differences were not significant.

The number and yield of stripped canes when harvested at the end of November were higher by 43% and 45% respectively for the crop from the lime-treated setts than those of the control. The correlation coefficient for number and weight of canes is positive, and highly significant for the untreated crop but not at all for the treated; thus the yield of untreated crop depended mainly on the number while for the treated, it was determined both by number and better development of each cane.

Soaking of setts in lime-water appears to be a desirable improvement in local practice in Malwa, where germination and yields are usually low, and perhaps in other parts of *India* too.

61. A note on the extent of growth (elongation) in the apical region of the shoot of the cotton plant.

B. M. Dabral *and* R. M. Ranji, Sakrand (Sind).

62. Studies on the growth of the cotton plant in Sind, Part I.

B. M. Dabral, T. J. Malkani, *and* S. S. Chiney, Sakrand (Sind).

63. Studies on the growth of the cotton plant in Sind, Part II.

B. M. Dabral, T. J. Malkani, *and* S. S. Chiney, Sakrand (Sind).

64. Results of germination tests conducted with seeds of paddy variety, *Vasiramundan*, preserved in different containers.

N. K. B. Kurupp, Travancore.

65. Some facts connected with the flowering of *Vasiramundan*, a paddy variety.

N. K. B. Kurupp, Travancore.

The paper is the result of a detailed, scientific study of the special and peculiar characteristics of a paddy variety called *Vasiramundan*, describing the experiments conducted on twenty-four plants of this variety. These experiments point to the conclusion :—

(1) That the *Vasiramundan* seedlings transplanted in the month of Karkadakam (Adi, August), as well as those transplanted in the month of Thulam (Alpasi, October), mature almost at the same time, thus demonstrating that conditions for its flowering are dependent upon stated and distinct seasonal conditions.

(2) That the prevailing wind, called 'Kizhekkan', is an important factor in determining the flowering of the plants.

(3) That the plantlings transplanted in the month of Karkadakam (August), having ample time before their flowering, are found to attain their maximum natural growth ; and

(4) That the sheath of the boot leaf is in every case longer than the sheaths of the leaves situated lower down, while the lowest green leaf has the longest blade.

66. Influence of the soil-moisture relationship on crop growth.

I. Madhusudan Rao, R. K. Aurangabadkar, *and* B. Goswami, Indore.

Moisture relationships at different profile zones were examined just after wet spells and after a rainless interval in three types of local soils, (1) poor, dark grey, liable to surface wash, (2) fertile, well-drained, black, (3) medium, light grey, well-drained, deep. Similar observations were taken on rich and poor patches in fields. In dry weather the black soil maintained a higher moisture level especially at the surface than the light grey deep soil, while the surface-washed soils showed extreme fluctuations. After rains, surface-washed soil and poor areas were moister than the others. The moisture content diminished in all soils from the top downwards to one foot and remained constant below. Under local conditions the passage of rain water to the permanent moisture level is slow and more so in poor fields, resulting in surface wash from unabsorbed rain, varying in severity inversely with the fertility.

The wet weather accumulation and the dry weather losses in the upper foot of the soil also vary similarly. The differences in moisture relationships in poor and rich soils seem to be associated with differences in cropping vigour not only in the kharif but also in the rabi season.

PLANT BREEDING AND GENETICS.

67. Improvements in plant breeding technique in relation to cotton improvement in Central India and Rajputana.

J. B. HUTCHINSON *and* KUBERSINGH, Indore.

Central India and Rajputana cottons are mixtures of poor yield and quality, with some components ripening late and liable to frost damage. Following 6 years' selection since 1925 and 4 years' confirmation on large-scale tests all over the area, strains emerged with yields more than 20%, staple 2 mm., ginning 4%, and spinning 40% higher than the Malwa locals; a roseum strain for Nimar yielding 20% higher; and an early Cambodia escaping frost for well or tank-irrigated areas of Malwa and Rajputana.

Imported varieties usually failed to thrive. Quick elimination of undesirables by exposure to local unfavourable conditions to detect hardy responsive families led to the success obtained. Final choices for multiplication and distribution were made rapidly and precisely by widely scattered field tests on Fisher's principles.

These principles have been further applied to eliminate similar undesirables in the early selection stages, to hasten the sifting of the products of previous hybridization, and to make further improvement in the already selected strains. The parent characters have been compared with those of their progenies.

Spinning values of products, even of single plants, are being assessed by the Indore *Takli* method.

Interspecific hybridization to concentrate desired genes promises striking products.

68. Ripening of sugarcane sorghum hybrids in the United Provinces.

H. N. BATHAM, R. L. SETHI, *and* L. S. NIGAM.

These sorghum hybrids behaved ununiformly at different stations, even at the same station in different years. At Cawnpore and Gorakhpur in the first year ripening started after nine months and maturation was incomplete even after eleven months, when only one of them recorded about 15% sucrose. In the second year at Gorakhpur ripening started after eight months instead of nine. Maturation was complete in nearly twelve months, when sucrose varied between 15·80% and 18·20%.

At Shahjahanpur maturation started after seven months (15% sucrose) and continued up to thirteen months, when maximum sucrose ranged between 17·25% and 19·95%. This difference in behaviour is probably due to the difference in the characteristics of soils and weather.

Compared with other Coimbatore varieties they appear to be richer and earlier ripeners than Co213 and Co350, but do not seem superior to other early varieties Co214 and Co313; and due to poor yield and defective agronomic characters they are not likely to replace them in the United Provinces.

If, however, advantage is taken of their early maturation and certain characteristics of soils, the working of sugar factories can be prolonged from October to May, and the loss generally undergone by the factories in the beginning of the season due to the supply of poor canes will be avoided.

69. Sugarcane and sorghum crosses in Malwa and Rajputana.

G. C. TAMBE, S. C. CHAKRABARTY, *and* V. R. SATHE, Indore.

The short duration of season favourable for the growth of sugarcane in Malwa and Rajputana makes desirable the growth of early types. Some of the Coimbatore Sugarcane and Sorghum Crosses, reputed for their extreme earliness, were compared with Coimbatore late varieties for the last two years. Some of them fared better than the late canes, in germination, growth and sucrose contents after nine months, though the yields of such early varieties were lower. The high-yielding crosses were not the highest in sucrose contents. It is yet to be seen whether suitable manuring will increase their sugar contents or the yield of the better analysing canes. Cultivation of early canes suitably adjusted to local conditions may prove valuable for Central India and Rajputana.

70. Mysore cottons and their improvement. Parts I and II.

V. N. RANGANATHA RAU, Bangalore.

Gossypium Arboreum is a perennial tree cotton belonging to the old world (Deshi) group, possessing a long and strong staple and at the same time developing a red flower and a green seed.

Several attempts in the past have been made to hybridize this cotton with other Deshi annual forms, with a view to transfer the quality of the staple into the annual variety, though not with much success.

A need arose to use this tree cotton as one of the parents in the hybridization work in Mysore, with the object of not only transferring the quality of the staple into the annual forms, but also the flower and the seed colour in order to distinguish it from the local cottons.

Three characters, namely, leafshape, flower colour, and seed colour, were studied in F. 1. and later generations.

After seven generations one form, possessing broad leaf, yellow flower, green seed, and at the same time having other economic characters, such as high ginning (over 30%) and superior lint, has been fixed, and this has been breeding true to the type during the last six seasons. (Further work is in progress.)

Two reports, one from the Technological Laboratory, Matunga, and the other from the Binny Mills, Bangalore, on the spinning performance of this cotton, are included.

71. The occurrence and inheritance of dimpling in sorghum grains.

G. N. RANGASWAMI AYYANGAR, SANKARA AYYAR, V. PANDURANGA RAO, *and* A. KUNHIKORAN NAMBIAR, Coimbatore.

Grains with a dimple on them occur in Sorghum. Varieties with such grains are rare. Dimpling has been noted in white, yellow, red and brown grains, and in grains that are pearly or chalky in appearance. Dimpling could occur in grains with floury or corneous endosperm. Grains from dimpled varieties are consumed as a delicacy in the dough stage when they are sweet. Dimpling results from the smallness of the starch grains. This smallness is due to the arrest in the development of the starch grains. The pollen in these dimpled varieties stain light-blue and in common varieties they stain deep-blue with iodine. In hybrids between dimpled and common non-dimpled varieties, gametic dimorphism, in both pollen grains and embryosacs, has been noted. Full non-dimpled grains in earheads with dimpled grains betray xenia. This dimpled grain occurs frequently in the group *S. cernuum* (Host) and the dimpled variety has been named *S. cernuum* (Host) var. *areolatus* (Rangaswami). Dimpled grains (dp) are recessive to normal non-dimpled (Dp) grains.

72. Inheritance of grain shattering in rice *Oryza sativa*.

K. RAMIAH *and* K. HANUMANTHA RAO, Coimbatore.

The shattering of grain is a character associated with wild, rices where it is most apparent. The cultivated varieties also exhibit this character in varying degrees. The inheritance of this character has been studied in the progenies of a number of crosses at the Paddy Breeding Station, Coimbatore.

The shattering character appears as a simple recessive in crosses involving a wild type as a parent where it is manifested to the maximum degree. The studies reported here, however, refer to a particular cross between two cultivated types which differed markedly with regard to this character, the mean number of grains shed per panicle in one parent being $3{\cdot}5 \pm {\cdot}013$ and in the other parent $34{\cdot}3 \pm {\cdot}534$. A special mechanical device was evolved to estimate the amount of shattering quantitatively in the parents, F_1s and subsequent generations up to F_3s. The results would appear to show that the inheritance conforms to the multiple factor type of inheritance for quantitative characters, and that the number of Mendelian factors involved are probably not more than two.

73. Introduction of improved varieties of crops in Central India and Rajputana.

J. B. HUTCHINSON *and* V. G. PANSE, Indore.

The results of over two hundred field experiments conducted by the Institute at Indore and in member-States in Central India and Rajputana during the three years, 1932 to 1934, are summarised. Chiefly due to research by the Provincial Departments of Agriculture in India there exist numerous improved varieties of common agricultural crops. The object of these experiments was to find those that could profitably replace the locally grown mixtures. There is no doubt that usually the greatest success will ultimately be obtained by selection from the local stock; but guided by these field trials, and as a first step in improvement some of the existing strains can be introduced with confidence in certain areas. Introduction of Cawnpore 520 cotton in the Gang Canal Colony in North Bikaner and Akola 12 groundnuts in Bundelkhand are examples.

Modern methods of field technique have been adopted throughout. Devices used to simplify the actual experimental work without loss of statistical accuracy have been described. Improvements to increase the efficiency of these trials have also been discussed.

ELECTRICITY IN AGRICULTURE.

74. Recent progress in the application of electricity to plant growth.

S. S. NEHRU *and* Co-workers, Mainpuri.

During the Presidential address in the session of 1934 the writer explained the results of experiments on the Application of Electricity to Plant Growth and stressed the different methods employed for a very wide variety of plants, the tendency of which was to turn from strong electric forces to weak and weaker ones. The most important practical methods were the radiomagnetic. These have since been developed, and new methods such as those of electrified irrigation and spraying tested by the writer and his co-workers of M.F.G. Association in the last 12 months. They cover mangoes, pears, jack-fruit, oranges, lemons, santras, falsa (*Grewia asiatica*), roses, guavas, grape-wines, sweet-lime, papaya, figs,

jamun (Eugenia jambolana), mulberry, plums and mushrooms. Especially favourable results with the electrified irrigation and spraying have been obtained with a wide variety of plants including cotton, cauliflower, maize, juar, etc. One very beneficial result of the treatment is to strengthen the stems of fruit so that they hold better and the loss of fruit falling in storms is very much reduced. Tests are in progress.

75. The use and benefit of irrigation and spraying with electrified water.

S. S. NEHRU, Mainpuri.

Electrified water is prepared by passing a high tension spark through water in an insulated vessel, usually an earthenware pitcher, for a minute or two. This water is then given to the roots or sprayed or poured over the growing parts of a plant. Root irrigation has proved very effective and water required for such purpose is much less than ordinary water for identical plants growing side by side treated as control. Among the plants which have given definitely favourable response in growth and in yield are orange, figs, papayas, cauliflowers, jamun (Eugenia jambolana), cotton, maize and lemons. As to spraying, this causes better growth of the growing part which receives the spray-bud, root, shoot, flower, leaf, twig, or anywhere else. This has proved very successful by the differential growth of fruit such as mulberry, roses, croton, hibiscus, etc. The theory very simply is that the growing part is, among other effects, surrounded with a mantle of electrified water which sets up a favourable potential under which the vital juices circulate with greater facility. This theory is of general application to tissues, plant and human, but has found special demonstration in these cases. Tests continue.

76. The cure and control of certain plant deficiencies, diseases and pests by electrocultural methods.

S. S. NEHRU *and* Co-workers, Mainpuri.

The methods employed are: radiomagnetic, high tension sparking of seed, electrified irrigation, spraying and gurwitch rays through onion interculture.

The following results have been registered to date:—

Withertip in Santra plants:—The treated growing vigorously; the control standing with few leaves.

Deficiency in Santra plants:—Two equal Santra plants taken for experiment. One jacketed and the other left control. The treated plant bearing 21 fruits and the biggest in the garden, the control only 3.

Smut on Sugarcane 290 and mealywing insect:—The Sugarcane plant infected with smut aproned and sparked for two minutes continuously for 10 days. After 12 days the treated plant gave 15 new healthy shoots which were growing vigorously. Mealywing insects were easily killed by sparking.

R.M. Bed sowing with control:—Potato sown in two pots E and C in hot summer. The E pot germinated and the C died.

Stem Borer in Papaya plants:—There were 7 infected plants which were jacketed after removing the infected portion of the plant. No sign of stem borer seen and plants are growing and fruiting normally and healthy as before. Tests have been repeated with success in many places (e.g. Mr. Slater's Farm, Etah).

Mango White Bug in Jack-fruit Plant:—One Jack-fruit attacked with insect jacketed and sparked with cycle dynamo for 5 minutes continuously for 7 days. On the 8th day ants were seen entering into small holes of the infected portion. The insects had died and the ants were eating it and the plant is now getting its original growth.

Energised seed sowing of (1) Cotton A 19, (2) Groundnut Akola, (3) Arhar Kartiki, (4) Castor.

All seeds energised separately and sown in pots with the control in the same soil and at the same time. Germination percentage of E was from 80 to 90 while the Control had 50%.

R.M. Bed sowing Jack-fruit :—The E seeds germinated 5 or 6 days before the control.

Some results of jacketing Mango Plants :—As the particular garden soil was unsuitable for the grafted mangoes, therefore every mango plant was aproned, the result being that none of the plants was affected either by frost in winter or by loo in summer. The small plants over a year old grew vigorously and the big ones four years old fruited heavily. Similar were the results with pumpkin and grape-vine plants.

Mulberry plants :—One mulberry plant which was energised in January 1935 fruited copiously. It has fruited again in the rainy season. Second series of fruits are as good as the first.

Cocoanut :—Plants that were dying began to revive and after another two weeks began to put out shoots.

Santras :—treated with Onion Interculture, not fruiting, having stunted growth, were improved in vegetative growth and threw out shoots. Others treated with jacket and Onion Interculture showed very good vegetative growth. Still others which had crumpled and poor fruit which would not ripen but fell off, gave a rapid response to treatment and improved in shape and are ripening on plant.

Var Mathena Rampur when treated with Onion Interculture gave new buds. General condition healthy.

Raspberries :—Treatment Radiomagnetic. Treated plants shows better growth and bears many fruits; controls smaller and have only a few fruits.

Bitter Gourd :—Treatment Radiomagnetic: Treated plant 7 times the control and budding early.

Tomatoes :—Treatment Radiomagnetic; treated plant bears big fruits.

Cabbage :—Treatment Radiomagnetic; treatment 1½ times the control in size.

Citrus suffering Malsecco :—is responding powerfully radiomagnetic treatment in tests conducted under the writer's care in Italy. Very significant is the following test :—50 seedlings were artificially inoculated with Malsecco. 25 left as control died out; the remaining 25 which were treated 50% are doing well.

AGRICULTURAL MARKETING.

77. Agricultural marketing.

A. M. LIVINGSTONE, New Delhi.

General Introduction. Nature of study now being made in India by Central and Local marketing staffs in Provinces and Indian States.

Discussion of survey methods with reference to the advantages of adopting a commodity basis. The compilation and interpretation of results.

Some aspects of the problem in relation to various commodities illustrating common factors and fundamental differences. Possible nature of subsequent development work with a view to improving marketing conditions and obtaining better returns for producers. Principles and methods of standardisation, demonstration (propaganda) and organisation (rationalisation) as adopted in other countries—applicability or otherwise to Indian agricultural conditions. Need for the assistance and co-operation of trade and manufacturing interests in improving marketing conditions. Conclusions.

MISCELLANEOUS.

78. Biological eradication of *Kans* (*Saccharum spontaneum*).

G. C. TAMBE *and* Y. D. WAD, Indore.

Eradication by the *Kans* plough or by chemical means, though efficient if properly done, was found, in practice, to be beyond the means of the Indian cultivator and not readily adopted by him. It was often seen that in one season complete destruction of patches of permanent grasses and weeds occurred wherever rain-watered compost was made or on field borders under heaps of collected weeds. This seemed to result from the smothering and decay of the roots in the presence of decomposing organic matter in the soil zone surrounding them, sufficiently to exhaust all reserve plant food. The injury is intensified by absence of light. Both in cultivated fields and grass areas *kans* patches were kept under cover of green or dry material during the monsoon after cutting away the standing growths. The process was repeated once in the season. The effect was striking, resulting in complete disappearance of the weed. A simple and cheap technique for a large scale adoption is being worked out.

79. Marom and marom infection (*Striga lutea* Lour).

N. K. B. KURUPP, Travancore.

Striga is a root parasite (Marom) generally met with in the cherikkal cultivation,—cultivation of paddy on the hill-slopes is known as 'cherikkal cultivation'. A careful study of it has revealed that deficiency of organic matter and of lime in the soil is a favourable condition for the growth of the parasite under reference. A few measures for the eradication of that obnoxious weed are detailed here as having been found, as a result of experiments, successful.

80. Soil conductivity and its water contents.

S. DATTA *and* K. N. CHATTERJEE, Calcutta.

81. The need for unofficial agricultural organisations in India and their scope.

T. V. RAMAKRISHNA AYYAR *and* V. MUTHUSWAMY AYYAR, Coimbatore.

In a large continental country like India containing vast areas of arable lands and forests and with the extraordinary varying agricultural conditions and practices, it is felt that the existing organisations under the auspices of the Government, for the purpose of bringing home and demonstrating to the Indian farmer in the fields the modern scientific improvements in agricultural methods and the multifarious benefits derived therefrom, are not sufficiently adequate and numerous to meet the growing needs of the cultivator in the different parts of this large continent. In this paper an attempt is made to make out a case for the need for unofficial agencies which can supplement the work of the Government departments in this direction. A few remarks are included regarding the scope of such organisations and some suggestions regarding the different methods that might be adopted to make them do useful work.

82. Agricultural bias in secondary schools; its nature and economic aspect.

K. A. PATWARDHAN, Indore.

Rural uplift work is mostly done at present by people unacquainted with practical agriculture. The sound footing and initiative with precision

necessary for success in such work can only be ensured if the right type of agriculture bias is given to future workers while at school. It is emphasised that the local conditions should be correctly reflected in every detail in the pattern adopted. The student thus initiated should then be acquainted with definite lines of possible improvements. All this should enable him to give a practical demonstration of what he may recommend to others. The Kumars of the Daly College, the future gentry of rural areas, are being made familiar with the local agricultural system including its economic aspect since July 1933. An account of the working of the scheme with results obtained is given with special reference to :—

(1) Capital Investment.
(2) Equipment.
(3) Current expenditure.
(4) Output.
(5) Training of students in carrying out farm operations and management.
(6) The evolution of agricultural training out of Nature Study taught in the lower classes, and
(7) Some examples of the practical effect of the training so imparted.

83. The waste products from educational establishments, and their utilization for educative purposes.

K. A. PATWARDHAN, Indore.

Four years' experience at the Daly College has clearly proved the utility of the Indore process of composting vegetable wastes as a sanitary system for the disposal of rubbish and stable wastes obtainable from the school compounds. It leads to economy in garden up-keep. The Daly College trials have applied, for the first time since its inception by Sir Albert Howard, the Indore process for the utilization of horse dung. A high quality of manure has been supplied to gardens in large quantities. Details about the available raw materials, working, water supply, labour, costs and output are given.

84. The use of revenue settlement records for agricultural workers.

K. A. SINGH, LAKSHMAN SWAROOP, *and* R. K. AURANGABADKAR, Indore.

With the help of information available in Revenue Settlement records, Agricultural Officers can carry out their advisory and research programmes with greater precision.

Productivity is the main basis of revenue classification of lands with a few exceptions due to economic and other considerations. Information is usually available in these records about, (i) texture and moisture-relations of soils, (ii) suitability for particular crops, (iii) response to manures and irrigation, (iv) characteristic natural vegetation, (v) topographical situations and associated rocks, and (vi) general weather conditions.

If it is realized that this classification brings soils of common affinities together even when they are situated in widely separated regions, its importance as a practical guide will surely be appreciated. Reports of field experiments ought, therefore, to state clearly the applicability of the results to the appropriate settlement classes so as to indicate the range of their extension in practice.

The revenue classification may facilitate the choice of typical sites for closer soil studies. It would be interesting to connect exactly if possible the settlement groups of soils with scientific classifications.

Instances from revenue records of Jodhpur, Alwar, Datia and Narsingarh are given to illustrate the above views.

85. Inheritance of Size and Shape of Grains in Rice.

S. K. Mitra *and* P. M. Ganguli, Assam.

The length of spikelets in rice has been observed to segregate in the ratio of 3 short: 1 long. But since there is a variation in the group of short and long spikelets within a limited range, a multiple factor hypothesis may also hold good for a multiple of the ratio of 3 : ·1

Multiple factors are also probably responsible for the inheritance of the breadth of spikelets in rice owing to the normality of the curves for the F_2 and F_3 segregations. Broadness has been found to be dominant over narrowness in F_1 of two crosses.

No correlation was, however, found to exist between the length and breadth of spikelets amongst the F_2 population of the cross made to study the spikelet size.

86. A note on the study of relationship between intensity of hairiness of cotton leaves and insect attack.

J. C. Luthra *and* Indar Singh, Lyallpur.

In the Punjab the foremost item on the programme for improvement of cottons was the introduction of American cottons with a view to provide to the Province strains of better quality fibre and longer staple than the indigenous cottons. In the beginning of this work it was realized that cotton varieties with smooth leaves or less hairy surfaces get seriously damaged by the Jassid insect. The character of hairiness of leaves became therefore one of the crucial determining factors on which selections of suitable forms had to be proceeded with. On basis of this important test a number of American selections were discarded and throughout the cotton breeding work attention has been paid to the extent of hairiness of leaves in various types. In certain years Jassid caused havoc among some outstanding selections and brought utter ruin of the crop.

As a result of these studies the following conclusions have been arrived at :—

(1) The intensity of hairiness varies in different types of American and Desi cottons. Desi cottons are distinctly more hairy.

(2) The extent of insect attack is related to the amount of hairiness of cotton leaves. Desi cottons being densely hairy are immune to the attack. The American types 6, 19, 35 and 38 are more susceptible to injury by Jassids as compared with types 1, 4F, 4F(S) and 43 which are more hairy.

(3) There is no appreciable difference in the length of hair of the different types of American cottons. Desi cottons, however, possess shorter and more hairs and those on the upper surface are comparatively longer.

(4) The leaves of American types, besides being less hairy are thicker than those of Desi cottons and are damaged greatly. The Desi cottons have thinner and more hairy leaves and are not injured by the insects.

(5) A statistical study of the relationship between hairiness and the number of brown damaged spots shows a high correlation; the coefficient of correlation being $-.95 \pm .039$. It means *that hairiness tends to check insect attack.*

87. The Importance of the Study of Hymenopterous Parasites in India with notes on the Bionomics of some of the Important Parasites found in Pusa.

E. S. NARAYANAN, M.A., Pusa.

Those who have followed the trend of Entomological thought in recent years must have been struck by the phenomenal interest shown in one of the branches of Economic Entomology, viz. 'The Biological Control of Insect Pests'. The Hymenopterous parasites belonging to the families Chalcidæ and Braconidæ play a very major part in keeping some of these pests under effective check. In India where the use of Insecticides is not possible or advisable due to the small holdings of the ryots, their illiteracy and poverty, and the prohibitive cost that the use of insecticides over large areas entails, the study of these parasites that silently bring about a partial destruction of these pests becomes very important. The biology of the following three parasites are described in the paper:—

(1) *Apantales flavipes* Cam.—This has been reared from the sugarcane stem borers *Argyria sticticraspis*, *Diatræa venosata* and *Chilo zonellus*. The parasite has not been definitely recorded in India before from either *Argyria sticticraspis* or *Diatræa venosata*. The parasite is first seen in the sugarcane fields from January onwards. From 15 to 80 *Apantales* grubs develop in each larva. The parasitic larvæ on their emergence from the host congregate in a group and move to the upper part of the bored tunnel. Moisture is essential for successful pupation and emergence. The pupal period is about eight days in March and the first half of April. Males and females emerge from the same cocoon. Males emerge first. They copulate almost immediately. Unfed they die in about 24 hours. If fed on sugar solution they live for three or four days. The males die earlier. Three to 18% of the cane borer larvæ were found to be parasitized.

(2) *Apantales paludicole* Cam.—The Pterophorid caterpillar *Sphenarachis caffer* feeds on leaves of *Lagenaria vulgaris*, *Dolichos lablab*, *Cucurbita* sp. and on the flowers and pods of *Cajanus indicus*. The pest is kept under check in nature by the parasite. The female parasite lays a single egg in the second instar larva of the host. The egg and larval period of the parasite inside the host body is 20 days in winter (November, December, January and first half of February), 15 days during the latter half of February and March, and 12 days during the monsoon months. The parasitization in 1933, 1934 and 1935 were 46.49%, 54.81% and 44.44% respectively.

(3) *Glyptomorpha deesæ.*—This has been reared from the root borer of cane *Emmalocera depressella*. This is the first time that the parasite is recorded from this pest. The parasites are seen in small numbers in the cane fields from the last week of April. The female with its long ovipositor is able to get at the larva in the root stock. The egg and larval period within the host is from 20 to 25 days. The males live only for 24 to 30 hours even if fed. The females live if fed for more than a week. The pupal period is about 12 days. The parasitization was about 3%.

Section of Medical and Veterinary Research.

President :—LT.-COL. H. E. SHORTT, I.M.S.

Presidential Address.

IMMUNITY IN PROTOZOAL DISEASES.

In choosing for my presidential address the subject of immunity in protozoal diseases I had two objects in mind. In the first place I was anxious to select a subject which would be of interest to both the Veterinary and Medical professions as well as to general biologists; in the second place I chose it as a subject with regard to which we have as yet little precise knowledge and which I wish to bring to your notice as well worth study by both professions and by other biologists. It is a field largely untrod when compared with similar fields in the domain of bacteriology and, therefore, likely to yield much interesting knowledge to the investigator. At the same time, comparatively fresh as the field is, I am aware of the limitations of my time and have had to omit much which might have been included had more time been available. Although, therefore, my selection has left much untouched I have endeavoured to deal with those aspects of most immediate interest to medical and veterinary workers.

Before taking up my theme, it will be necessary for me to attempt a definition of immunity. This is a word which has been very hard worked in medical science and I wish to make clear the limitations of its use in my present communication. By the term immunity I wish you to understand the resultant between the opposing forces of the invading parasite and the invaded host. As both host and parasite share the common biological characteristic of never being in a state of equilibrium, so the resultant of their interactions is always varying and may, at a given moment, have any value from zero to infinity. This definition is wide enough to allow us to consider immunity both from the point of view of the host and the invader.

I think there has been a tendency in the past for medical and veterinary biologists to consider that immunity of the host against the attacks of protozoa differed in its mechanism from that against the attacks of bacteria. This attitude was probably engendered by the fact that after the attacks of certain protozoal diseases, immunity appeared to be very evanescent or even non-existent. I refer to such diseases as malaria and amœbic dysentery repeated attacks of which an individual may suffer from. In the former case, not only does cure leave the individual

still susceptible to infection with malaria but even before cure each individual relapse does not confer sufficient immunity to prevent further relapses. Under such circumstances, it was not unnatural to conclude that there was no appreciable immunity conferred by an attack.

A consideration, however, of all the recent literature on immunity against protozoal diseases makes one believe that immunologists are being led to the conclusion that the mechanisms of resistance on the part of the host to invasion by protozoa and to multiplication of the latter in the host's body are similar to if not identical with those brought into action against bacterial invaders.

This being so, it is necessary for me, as a preliminary, to review very briefly, for the benefit of those here who are non-medical or veterinary biologists, and with apologies to these latter, some of the known mechanisms by which immunity against specific infections is brought about. In doing this, I have followed closely the views expressed by Topley in his extremely useful ' Outline of Immunity ' which is a masterpiece of condensation without the omission of any essentials.

Immunity comes into action when an infection, bacterial or otherwise, has invaded the tissues of the host. To prevent this invasion, there are various inhibitory mechanisms. Some of these act chiefly as mechanical barriers—such are the intact skin and mucous membranes. Others act by virtue of chemical agents—such are the stomach with its gastric juice of high hydrogen-ion concentration. Still others act by means of a bacteriolytic agent called lysozyme which is present in tears, nasal secretion, and many tissues, including skin.

The nasopharynx is another barrier. In this bacteria are caught up in the mucus and swept back by the agency of ciliated epithelium to join bacteria from the mouth on their way to the stomach. Enough has been said to show that any pathogenic organism which has gained access to the tissues has done so by evading or breaking down a series of barriers erected against it and the host may be said to have lost the first action against the invader. Let us now see what the internal lines of defence against the enemy are.

Antibody Formation.

When certain foreign substances, particulate or in solution, are introduced directly into the blood or tissues of an animal, they stimulate the production, in the serum or body fluid of that animal, of specific substances which, when brought in contact with the specific stimulants, react with them in some observable way. The substances acting as stimulants are called *antigens* and the resulting specific substances which react with them are called *antibodies*.

The usual method of proving the antigenic nature of any body is to show that when mixed with the serum containing the homologous antibody there is formed either a precipitate if the antigen is in solution, such as a toxin, or aggregates of particles if it is particulate, such as a bacterium.

Now it is almost certain that all substances which are complete antigens are protein in nature and it follows from this that specific immunity is dependent on chemical structure.

The next question that arises is what is the chemical nature of antibodies. There is not a great deal known about this but it is possible that they are either globulins or very intimately associated with the globulin molecule. Thus in serum they are almost invariably found to be present in the pseudoglobulin or euglobulin fractions.

We have now to consider the various reactions which may occur when antigen and antibody are brought together.

Agglutination.

We may consider this first as it is probably one of the most commonly practised of all bacteriological procedures. In this reaction, the antigen is an organized cell or part thereof. The antibody may have been produced naturally in the serum by an attack of disease or artificially by the parenteral inoculation of the corresponding antigen. The reaction consists essentially in the mixture of a suspension of the antigen (e.g. *B. typhosus*) with the corresponding antiserum. The antibody in the latter causes the aggregation of the bacteria in the suspension into clumps.

Lysis.

By this is meant the power possessed by serum of disintegrating bacteria and other cells. This property is due to the presence of specific antibodies whose presence has been determined chiefly by the injection of the corresponding antigen. It has been shown, however, that this lytic property of immune sera is dependent on two substances—(*a*) the specific lysin which is relatively heat stable, (*b*) the complement which is thermolabile. The complement is present in normal serum and in contrast to the lysin is not increased as a result of the introduction of foreign proteins.

Precipitins.

When an antigen in solution is brought into contact with its corresponding antibody, there is a reaction in the form of precipitation in the mixture. The greater part of this precipitate comes from the antiserum.

Complement Fixation.

This reaction was first described by Bordet and Gengou. It depends on the fact that under appropriate conditions when antigen and antibody combine they have the property of absorbing complement.

The reaction may be applied for the detection of either antibody or antigen although it is usually applied with the former object as in the well-known Wassermann reaction.

Opsonins and Bacteriotropins.

Normal unheated serum contains bodies which so act on bacteria as to render them more sensitive to phagocytosis and on account of this property of preparing bacteria for ingestion, they are called opsonins. The opsonins are thermolabile.

Antibacterial sera have been shown to contain specific antibodies of similar function which prepare bacteria for ingestion by phagocytes but are thermostable. This character differentiates them from opsonins and they have been called bacteriotropins. The mode of action of these bacteriotropins is probably closely allied to that of agglutinins, precipitins, and lysins.

Having now reached the stage where we have reviewed, although in mere outline, the various reactions concerned in the production of immunity we may consider for a moment the theoretical concept in terms of which these reactions may be explained. The classical theory is that of Ehrlich—the side-chain theory. This theory is not now accepted in full but, if it is modified in accordance with knowledge now available, it forms a very good working hypothesis. Ehrlich's theory may be briefly described as follows.

Every cell of the body has side attachments (chains) whose normal function is to fix food materials and if necessary so to alter them as to make them suitable for assimilation by the cell. These side attachments are called 'receptors'. When antigens are introduced parenterally into an animal's body, they attach themselves to these receptors and the latter are therefore diverted from their proper function of fixing food materials for the cell. To make good the deficiency, the cell produces more receptors and, as commonly occurs in nature, these receptors are produced in excess. This excess of receptors is shed into the body fluid and it is these excess free receptors which constitute the antibodies in the serum. Ehrlich further emphasized his belief that the specificity of the antibodies was determined by chemical structure and that the union of antigen and antibody was a chemical one. This is the baldest possible statement of Ehrlich's theory and I think it is unnecessary to go into further detail here.

We have now to consider whether the various reactions we have considered, and which are the observable evidences of immunity production, i.e. agglutination, lysis, precipitation, complement fixation, etc., are all the result of interaction of the antigen with different kinds of antibody or with the same antibody performing different functions. The latter conception is now almost universally accepted and may be expressed shortly in the following terms: The union of antigen and antibody takes the form of an aggregation of globulin particles around the antigen. The result of this union at the surface of a cell sensitizes it equally to lysis by complement, phagocytosis by leucocytes, and flocculation by electrolytes. The degree to which one or other effect is brought about depends on the relative proportion of antigen and antibody, the nature of the antigen vector (cell or bacillus, etc.) and on other factors, i.e. all the serum reactions are but different ways of making observable a single reaction.

We are now in a position to study the part these factors play (if any) in diseases caused by protozoa. The most convenient way in which to do this will be to take certain specific diseases and to see what is known about each as regards the presence or absence of immunity in the parasitized host. The evidences of immunity are not so easily brought under observation in the test tube as in bacterial diseases and have, therefore, to a greater extent to be studied in living animals. Thus many protozoa are confined to internal organs or tissues such as the coccidia and, also, many cannot be cultivated artificially. Under these conditions, the protozoal infections most amenable to study from the point of view of immunity are those in which the parasites occur in the peripheral blood of the host in all their stages and thus can be seen, measured, and enumerated. For our purpose, it will be most convenient if we take certain representative protozoal infections and study the immunological reactions in each.

TRYPANOSOMIASIS.

The trypanosomes are among the most suitable of all protozoa for study on the lines indicated above because, in most of them, all their stages in the vertebrate host are to be seen in the peripheral blood. The account which I am about to give follows the findings of W. H. Taliaferro who has done as much as any one to elucidate immunity responses against protozoa.

The trypanosomes multiply by a process of binary fission and it is therefore evident that, in the absence of any inhibitory effect exercised by an immunity response on the part of the host, the number of trypanosomes will increase by geometrical progression in the form 1, 2, 4, 8, etc. If, on the other hand, this uniform progression is not displayed, and the parasites

remain stationary in numbers or decrease, it is evident that some retarding influence is at work. It may fairly be assumed (although it does not logically follow, since the parasite might conceivably limit its own fertility after an optimum concentration in the blood had been reached) that this retardation is due to an immunity response developed by the vertebrate host.

The most accurate method of determining whether such an immunity is operative and of estimating its effects is to make a number curve of the parasites in the peripheral blood. The causes of fluctuations in this curve, if any, have then to be investigated. They may be brought about by one or both of two causes which are essentially independent defence mechanisms. These two mechanisms are—

(*a*) retardation or complete inhibition of the rate of reproduction,
(*b*) destruction of parasites.

From these considerations it will be evident that the position of any point on the number curve will be determined by the number produced by division minus the number destroyed. This would give us the equation

$$X = R - D,$$

where X is the number of parasites at any specific time,
R is the number produced by division,
D is the number destroyed.

X is simply determined by any of the means of enumeration of parasites, but R is independent of both X and D. R, the number produced by division, cannot be exactly measured, but an approximate measure of the rate of reproduction can be arrived at in two ways. The first of these is by obtaining the coefficient of variation of the lengths of the trypanosomes. This procedure is based on the fact that when an organism is undergoing rapid multiplication there will be a constant production of young forms and therefore intermediate stages of growth up to the mature forms. If, therefore, a given number of forms is measured, say 100, there will be great variations in size among the individuals. On the other hand, if little reproduction is going on the majority of the individuals will be mature forms and approximately equal in size. From the number measured the mean size of parasite at any specific date in the infection can be determined and from the same data the coefficient of variation determined by the usual formula. For a given trypanosome, e.g. *T. lewisi*, a coefficient of variation for length of 3 per cent. indicates that the trypanosomes are all adults and there is no multiplication going on while one of 30 per cent. indicates very active multiplication.

The second way of determining the approximate rate of

reproduction is by ascertaining the percentage of dividing forms in an infection.

We may now study the results obtained by applying these methods under experimental conditions. To do so, we shall study the effect of infecting animals with both pathogenic and non-pathogenic trypanosomes.

Pathogenic Trypanosomes.

Let us study the course of event when a white mouse is inoculated with a pathogenic trypanosome such as *T. rhodesiense*.

There is found to be a short incubation period of about four days. After the first appearance of parasites in the blood, there is a continuous increase in numbers until the death of the mouse in about eight days. What do our methods of study already described show? In the first place, if counts of parasites are made at regular intervals throughout the infection the number curve will be found to ascend almost perpendicularly without any fluctuations, proving the continuous increase in numbers by geometrical progression. In the second place, the coefficient of variation curve for size remains fairly high—say 10 per cent.—throughout the infection indicating that a constant rate of reproduction is maintained. This fact is corroborated by the presence of dividing forms in the blood. Our reading of these data is that the host exhibits no immunity whatever to this parasite, either in the form of parasiticidal activity or in that of lowering the rate of reproduction.

As a contrast to the last example, let us now study what occurs when the same parasite is inoculated into a guinea-pig.

In this case, after an incubation period of four or five days, a few trypanosomes are seen in the blood. These increase but do not reach a very high level in numbers and are subject to periodic increases and decreases ended by the death of the animal in four to six weeks. By applying the same methods of investigation as in the case of the mouse, we find that the decreases in number, called crises, and the subsequent increases, called relapses, appear on the number curve as fluctuations in contrast with the uniform ascending curve found in the case of the mouse.

The coefficient of variation curve for lengths remains remarkably constant and at the comparatively high level of about 10 per cent. or over. What are we to read into these observations?

The sudden disappearance of parasites from the blood, represented by the rapid descent from the peak of a wave on the number curve, is presumably due to a sudden rapid destruction of parasites. The alternative suggestion that it may represent a mere withdrawal of parasites from the peripheral

circulation may be dismissed because a post mortem reveals no accumulation of parasites in any internal structure. The fact that the coefficient of variation curve for length of parasite remains constantly at a comparatively high level is evidence that reproduction is going on continuously at a uniform rate. The sudden disappearance of parasites at crises, as well as their comparatively low numbers throughout, when compared with happenings in the mouse, is further evidence that destruction of parasites is going on. As nature always seems to avoid reaching 100 per cent. in anything a few parasites escape and, since the rate of reproduction is unaltered throughout the infection, these repopulate the blood, leading to the successive relapses and crises until the death of the animal.

To summarize the effects of immunity in this case we may say that it is only partially successful since, in the end, the animal dies. The guinea-pig's immunity mechanism is here limited to a destruction of parasites by one of the mechanisms of immunity previously considered by us, viz. lysis, but fails to produce any effect on the rate of reproduction.

A consideration of these results in mouse and guinea-pig seems to me suggestive. Have we here a possible explanation of the method in which the non-pathogenic trypanosomes and their hosts adapted themselves to each other? We have seen that the mouse exhibited no immunity to *T. rhodesiense* and was killed with the simultaneous destruction of the trypanosome —a futile biological experiment. The guinea-pig was more successful and withstood the infection for some time while the parasite was still able to maintain its existence. Now comes the crucial point. If we can imagine an animal a little more resistant than the guinea-pig, to the point of being able to preserve its own life while still unable to mobilize sufficient immunity completely to destroy the trypanosome, we arrive at a working arrangement between host and parasite in which the host supplies a habitat to the parasite and the latter makes the minimum of demands on the vitality of the former. If such a condition were established it is but natural that more complete adjustment would ensure with the lapse of time and so there might become established a perfect adaptation between host and parasite such as apparently exists in the case of the non-pathogenic trypanosomes such as *T. lewisi.*

To resume our study of the guinea-pig, it has been stated that the destruction of the trypanosomes was due to lysis. There is much experimental evidence in proof of this and also that the repopulation of the blood by trypanosomes after a crisis is not due to the disappearance of the trypanolytic substance but to a biological change in the trypanosomes which renders them insusceptible to the *trypanolysin.*

Thus it has been found that the blood of the vertebrate host may contain both trypanosomes and powerful trypano-

lysins, direct evidence that to resist the latter the trypanosomes must have become biologically altered. It has also been demonstrated that these trypanocidal properties of the blood are developed at the crisis and that whereas they do not act on the trypanosomes present after the crisis they destroy the original pre-crisis strain. It has also been shown that the pre-crisis strain and the relapse strain are so different biologically that they can be differentiated by cross-immunity tests. Thus a mouse cured of its infection with drugs is insusceptible to the original strain but may be infected by a relapse strain and *vice versa.* Various explanations of this acquisition of resistant powers by the post-crisis trypanosomes have been given. Ehrlich explained it on his side-chain theory. He held that the receptors of the original strain combined with the trypanocidal antibodies. New receptors were formed on the parasites which could not combine with the antibodies and hence the parasites were resistant. Others have explained the phenomenon on the assumption that non-resistant parasites were killed by a process of selection and resistant parasites alone remained. Others have considered that the serum contained a substance which had the specific property of producing resistant strains.

It has also been shown that the trypanolytic action is a complement-amboceptor phenomenon, thus bringing it into line with other lytic immune phenomena. The trypanocidal substance is present in the globulin fractions of the serum, especially the euglobulin.

The reproduction-inhibiting component of the serum is also present in the globulin fractions, especially the euglobulin. This question of biological alteration of the trypanosomes is an amazing one when one considers that in certain experiments it has been shown that a mouse incompletely cured 20 times produced 17 immunologically different relapse strains. Differences between original and relapse strains can be demonstrated in other ways than by cross immunity reaction, e.g. by Rieckenberg's platelet adhesion phenomenon but time does not allow me to go into them.

The phenomena we have been considering raise the question as to whether the trypanolytic action of serum can be demonstrated in the mouse, which has no natural immunity. This is found to be the case. Thus, if the serum from a guinea-pig after the crisis of an infection with *T. equinum* is injected into a mouse infected with the same parasite an artificial crisis is produced within an hour or so. The parasites later reappear and then multiply steadily until the death of the mouse, since the temporary immunity is merely passive.

Non-pathogenic Trypanosomes.

Having dealt with the pathogenic trypanosomes and got an idea of some of the immunity mechanisms at work we can

deal with the non-pathogenic trypanosomes more shortly. As a type of these we may take *T. lewisi* parasitic in the rat all over the world. An infection with *T. lewisi* takes the following course.

There is an incubation period after which the organisms appear in the blood and increase rapidly in numbers until the blood may be swarming with them. There is then a crisis and most of the trypanosomes are destroyed. The survivors continue in the blood with little or no increase in numbers until there is a second crisis and they also are destroyed. Hereafter, the rat is immune to infection.

If this course of events is studied by the methods previously described, i.e. the working out of number curves and coefficient of variation curves for length it will be seen at once that a different state of affairs exists from that seen in an infection with a pathogenic trypanosome. If the number curve in a typical infection is examined it will be found to rise sharply between the third and sixth days, indicating rapid and uninterrupted reproduction. From the sixth day onwards, the increase in number of parasites is retarded until by the tenth day all the parasites are mature and no further increase in numbers is occurring. The curve then falls by crisis, indicating the destruction of large numbers of trypanosomes. It then maintains a comparatively low level for some time (weeks or months) but may rise again, followed by another crisis, and the total destruction of the trypanosomes.

The curve for coefficient of variation in length is also in contrast with that for pathogenic trypanosomes. The first appearance of parasites in the blood coincides with a very high position of the curve, in the neighbourhood of 25–30 per cent., but the curve falls rapidly to a minimum about the tenth day, coinciding with the beginning of the crisis. The curve thereafter remains at a fairly constant low level of about 5 per cent.

These observations correspond with what would be noted by daily microscopical examination of the blood and indicate that the manifestations of immunity take three forms:

(1) A retardation and eventually almost complete cessation of reproduction by about the tenth day.
(2) A sudden destruction of parasites by lysis about the tenth or eleventh day.
(3) A total destruction of parasites terminating the infection after weeks or months.

Without going into the details of experiments in proof of the assertion I may say that it has been shown that the anti-reproduction mechanism is quite independent of the bacteriolysin and acts *only* by inhibiting reproduction without killing the trypanosomes.

As regards the second crisis which terminates the infection there is some doubt as to the parasiticidal mechanism at work. By some it is supposed to be a lysin, by others due to phagocytosis, or a combination of both.

To sum up the serological immunity responses shown against pathogenic and non-pathogenic trypanosomes we may say that in the case of pathogenic trypanosomes the host either shows no resistance (mouse) or at intervals forms a trypanolysin (guinea-pig) which is not absolutely effective as it does not kill all the trypanosomes and the survivors renew the infection periodically until the death of the animal. In the case of the non-pathogenic trypanosomes the host produces a reproduction-inhibiting antibody in addition to the lysin and in consequence each trypanolytic crisis is ground gained by the host, since surviving trypanosomes cannot multiply to replace the loss and so, eventually, the host reaches complete sterility.

Other Parasiticidal Mechanisms.

The only mechanism we have so far considered which destroys the trypanosomes is the lysin, but there are other agencies which also play their part and must be considered.

Phagocytosis.

The engulfment and destruction of trypanosomes by phagocytic cells may be seen both in the peripheral blood and in the internal organs containing fixed phagocytic cells such as the liver and spleen. If trypanosomes are injected into the peritoneal cavity of immune animals or into susceptible animals with the addition of immune serum there is an enormous influx of leucocytes, chiefly mononuclears, which first attach themselves to and then engulf and destroy the parasites. This phenomenon of phagocytosis can also be demonstrated *in vitro*.

As regards the fixed phagocytic cells the chief tissue reaction to trypanosome infection is said to be a stimulation of the reticulo-endothelial system, within the cells of which trypanosomes may be found in all stages of digestion. The relative importance of this immunity mechanism and those shown by the serum is not easy to assess and it is possible that they may both be different expressions of one process, since the preliminary attachment of phagocyte and trypanosome preceding engulfment may be caused by a lytic serum.

Alterations in Blood Sugar.

There is some evidence to show that the destruction of parasites is accompanied by a lowering of the amount of sugar in the blood. This effect can be demonstrated *in vitro* as well

as *in vivo.* How important this mechanism may be is not known as there may also be a hypoglycæmia in animals such as the mouse which show no successful immunity response to pathogenic trypanosomes.

MALARIA.

Our study of immunity reactions in trypanosomiasis will enable us to deal somewhat more shortly with malaria since the mechanisms at work are probably very similar and these have already been explained. The chief difficulty in the study of the immunology of malaria in the past has been the lack of a suitable experimental mammal since animals are not susceptible to the human disease. As we shall see later this difficulty no longer exists and, as a result, much knowledge is already being accumulated. Most of the work in the past has been done with bird malaria and with this we must first deal.

BIRD MALARIA.

Let us first see if we can apply the methods used for the trypanosomes.

With the trypanosomes we found a measure of the rate of reproduction could be ascertained by determining the coefficient of variation for length (size) of parasite. This was easily done because there was reproduction by binary fission without any periodicity. In an infection with malarial parasites, however, the asexual forms in a simple infection grow and sporulate synchronously, i.e. at any one stage all the forms will be either large, medium, or small. The time required to complete the cycle from any stage back to the same stage will be a measure of the rate of reproduction of the parasite. To make the computation a given number of parasites is measured at four-hour intervals over a reasonable period of the infection. The data represented graphically show a curve with violent oscillations at regular intervals. This is due to the sudden change in size from the large schizont to the small merozoit. If such curves be drawn at different stages in the infection—acute, chronic, and relapse—they would show any alteration in the rate of reproduction. In malaria this method replaces the coefficient of variation for length method used for trypanosomiasis and, like it, is independent of the number of parasites destroyed.

The parasite of bird malaria has the usual sexual and asexual cycles but it is only with the latter, occurring exclusively in the vertebrate host, that we need deal. The usual course of an infection is as follows.

After an incubation period parasites appear in the blood. They rapidly increase in numbers till there is a very heavy

infection. A crisis supervenes and most of the parasites are killed. After a time no parasites are seen in the blood, indicating a latent stage in the infection. At any later stage relapses, followed by crises, may occur. These stages will now be considered in turn.

Incubation Period.

It is self-evident that there can be no immunity during the incubation period else the small number of parasites present would be destroyed. Further evidence, however, is supplied by the fact that the incubation period is to some extent proportional to the number of parasites injected, indicating that the rate of increase in parasites is probably constant and that the incubation period is simply the interval between the infection and the time necessary for the parasites to increase in numbers sufficiently to be found in the blood.

Period of Acute Attack.

If the method of measuring the rate of reproduction be now applied to the period of increase in the number of parasites it will be found that the length of the asexual cycle will be constant, e.g. 24 hours, showing that the rate of reproduction is constant and that the number of parasites increases by geometrical progression. This is an indication that the numbers are increasing unchecked and that there is no immunity response at this period. It must not be inferred from this that all the products of schizogony survive, probably only about one-third do, but the survival rate is constant and the death-rate of two-thirds is probably merely a measure of the natural suitability of the host for the parasite.

The Crisis.

No one has been able satisfactorily to demonstrate the existence of any antibody responsible for the crisis. Certain possible factors may be considered.

The destruction of parasites is brought about without any retardation of the rate of reproduction, which remains constant throughout the infection. The parasiticidal mechanisms at the crisis may be an enhancement of the natural unsuitability of the bird for the parasite, represented, as has been stated, by a two-third mortality among the merozoits, but this is mere supposition and there may be a more active parasiticidal mechanism in addition.

Another possible cause is phagocytosis by the blood and fixed tissue phagocytes. That there is a great deal of phagocytosis is certain and this may be brought about in various ways, although the full mechanism of the method chiefly responsible

is uncertain. There may be some antibody mechanism rendering the parasite or red cell-parasite combination more liable to phagocytosis. It may, on the other hand, kill the parasites by lysis, so that devitalized parasites, as well as parasites and red cell débris, are phagocytosed. The reticulo-endothelial system itself may show a hyperplasia leading to an increase of non-specific phagocytosis.

The question of blood sugar decrease, previously mentioned, may also play some parts in the process.

Latent Period.

Various theories to account for this stage in infection have been advanced but time will only permit me to do very little more than mention them. A relapse may occur after a short interval or after a very long interval and it is possible that the method of survival of the parasite may not be the same in these two cases. In the case of relapses after short intervals most observers agree that there is a persistence of the asexual parasites in small numbers throughout and that some lowering of vitality, or the relaxation or temporary failure of the immunity mechanisms, allows a repopulation of the blood to produce a relapse. In the case of relapses after a long period some workers hold that the same factors are at work. Other theories, however, are in the field. Thus, parthenogenesis of the female gametocytes has been advanced as the source of parasites in a relapse but this is hardly accepted now. Other workers have described specialized resistant asexual forms able to retain their vitality in the body of the host during a latent period and capable of resuming the schizogenic cycle at a propitious moment. I think on the whole the balance of evidence is in favour of a continuity of asexual reproduction at a low level during the latent period. This view is lent strength to by the fact that in bird malaria, when no parasites can be seen in the blood during a latent period, the blood is still infective when inoculated into a susceptible bird, showing that at least a few asexual parasites must have been present, since these are the only ones which could have infected a new host. It has also been shown that during the latent period, if parasites were found at all, asexual reproduction was not only taking place but *at the same rate* as during the period of rise of the infection.

The destruction of parasites which is going on in a latent infection can be very beautifully illustrated by injecting a known number of washed parasitized blood cells into two birds—one a bird with a latent infection, the other a normal bird. In the first case, the parasites are removed within a day whereas in the second they increase uninterruptedly to produce a normal infection. It has been shown repeatedly that such attempts to superinfect a bird with a latent infection will not succeed

whereas a bird, definitely cured, can easily be reinfected. This would appear to show that *immunity is only present while the host still contains living parasites.* This immunity to super-infection is specific and infection by a different parasite of bird malaria is possible during the latent period. The highly effective mechanism producing this immunity during the latent period has been shown by experiments to be in no way associated with a protective antibody in the serum, i.e. it is not a humoral immunity. More recent work has shown that the parasiticidal mechanism in action at the crisis and during latency is overwhelmingly a cellular one. This is shown by a study of the reticulo-endothelial system of normal and latently infected birds when inoculated with parasitized red cells. The following findings are recorded:—

1. The unit phagocytosed is the red cell-parasite combination and not the released free merozoit.
2. Phagocytosis commences within four hours of infection and is continuously present during the acute period, reaching a peak at the crisis.
3. There is a definite activation of the mesenchyme of the liver and spleen commencing within 18 hours of infection and increasing progressively during the acute stage of the infection.
4. The phagocytic cells are the macrophages (Kupfer cells, splenic pulp cells, etc.).
5. The activated condition of the mesenchyme persists during the latent period so that active phagocytosis is at all times in action.
6. The activity of the mesenchyme lasts as long as any parasites remain in the host.

The mechanism of immunity in bird malaria may therefore be said to be due to the activity of the reticulo-endothelial system resulting in an actual increase in numbers of phagocytic cells and an increased phagocytic activity of these cells.

If one compares relapse in malaria with that in trypanosomiasis, then, one finds that in both reproduction is maintained throughout the infection at a comparatively constant rate and this rate is not affected by the parasiticidal mechanism which destroys parasites at a crisis. The return of parasites into the circulation, however, is due to a different cause in the two cases. In malaria it is due to a temporary suspension of the parasiticidal mechanism while in trypanosomiasis it is due to development of a resistant strain of trypanosomes from those which have survived a crisis.

Mammalian Malaria.

The discovery that certain species of monkey malaria are transmissible not only to the homologous monkey but to other

species has put in our hands a most convenient means of studying the malaria parasites of mammals. Here, however, a word of warning is necessary. One of these parasites, which has been extensively studied, is *Plasmodium knowlesi.* This occurs naturally in *Silenus irus* to which it seems to behave much in the manner of a non-pathogenic trypanosome to its host but it can be transmitted to other species of monkey. When it is used to infect *S. rhesus* a very severe and rapidly fatal attack of malaria ensues and this monkey appears to have little resistance to it. It is obvious, therefore, that its behaviour in this monkey must not be considered as its normal habit and it would be unsafe to draw inferences from its behaviour in *S. rhesus* and make them generally applicable. On the other hand, the *S. rhesus-P. knowlesi* combination is an extremely useful one for study provided these considerations are kept in mind.

In the case of human malaria in a hyperendemic area the usual course of events among the human population has been often described. During the first two years of life 100 per cent. of the children are infected and there is a spleen rate of nearly 90 per cent. Many of the children die and all are ill at frequent intervals, because they are continually exposed to bites by infected anopheles. This state of affairs is called 'acute infestation'. Between the ages of 3 and 5 the spleen rate may be as high or higher but the parasite rate is lower and attacks of fever are less frequent. This marks the commencement of 'immune infestation'. Between the ages of 6 and 10 the spleen rate has fallen to about 70 per cent., the parasite rate is lower and there is less fever. This is the state of developed 'immune infestation'. In adults the spleen rate may fall to about 10 per cent., the parasite rate may be low, and attacks of fever are infrequent. It is evident from this sequence of events that the community as a whole acquires a relative immunity after about 12 years' exposure to infection. This cannot be called a triumph for the immunity mechanism against malaria and this point will be discussed later.

Mechanism of Immunity in Mammalian Malaria.

In considering this we have, in the past, had to rely largely on clinical data and post-mortem findings but it is hoped that now monkey malaria will give us great additions to our knowledge. It has been stated as the result of recent work on the treatment of general paralytics with malaria that individual susceptibility to malaria varies greatly. This may or may not be true but I do not consider it to be a fair inference from such data. The patients treated are probably adults and they have usually been subjected to the effects of various drugs. The conclusion ignores, also, the fact stated above that in a hyper-

endemic area 100 per cent. of children may be found infected. Attempts to demonstrate the presence of immune bodies in malaria cannot be said to have had much success but the actual sequence of events in malarial infections seems to indicate that these, in some form or other, must be present. Complement fixation tests by various techniques have been carried out using various antigens such as cultures of parasites, alcoholic extracts of infected spleen and liver, and extracts from the stomachs of infected mosquitoes. It is stated that the presence of antibodies could be demonstrated but the results were uncertain and the reactions feeble.

By some workers precipitin tests are stated to have given a specific antigen-antibody reaction. The antigens used have been infected placenta appropriately extracted, cultures of malarial parasites, etc. The curative action of sera from chronic malaria cases has been investigated with results said to be of benefit and skin reactions in malaria have been demonstrated by the use of extracts of malarial parasites.

Phagocytosis.

We have already seen the importance of phagocytosis in bird malaria. Is it equally important in mammalian malaria? The enormous collections of pigment seen in the spleen and liver at post mortems on malaria cases leaves no doubt as to the function of the reticulo-endothelial system in clearing up the débris of malarial infection. Is it also active against the parasite when the latter is still a viable and healthy organism? I maintain that this has never been satisfactorily demonstrated. It is perfectly true that in some malarial infections there may be seen macrophages containing apparently unaltered parasites, both in red cells and free, and in some cases these may even be numerous. At the same time the evidence of most workers with much experience of the routine examination of malaria slides is all to the effect that such preparations are rare, and therefore, not to be taken as evidence of what normally happens. Preparations such as those mentioned above often indicate what is seen in moribund cases where specific immunity has completely broken down and only the non-specific capacity of macrophages to ingest foreign bodies remains. There is really nothing to show that the parasites ingested have not already been rendered unviable by some other immune mechanism before the overwhelming of the defences of the body by a very virulent infection. This is a question which should now be easily cleared up by the study of monkey malaria and it would be more justifiable to apply the findings to human malaria than to have done the same with the findings in bird malaria.

That phagocytosis is an important concomitant of the destruction of malarial parasites goes without saying but whether

it is the prime agent is less certain. Some evidence to this effect is provided by the observation that in certain experiments where normal and splenectomized monkeys were compared, the former, on inoculation, acquired moderate infections, which responded readily to treatment, while the latter acquired rapidly fatal infections which did not respond to treatment. This is presumptive evidence of the essential part played in immunity by the reticulo-endothelial system but it does not prove that this part is necessarily phagocytosis ; also, a monkey without its spleen is no longer a monkey and cannot fairly be compared with one which is intact. It seems not unlikely that some antibody or some mechanism which becomes activated as a result of the infection may sensitize the red cell-parasite complex in such a way as to render it readily phagocytisable and this action may be brought about through the agency of the reticulo-endothelial system.

In this connection, there has been some very interesting work done in respect of the electrical charge carried by red cells in bird malaria. It is well known that bacteria carry a negative charge and that this is reduced in the presence of a suitable electrolyte and immune serum, as shown by a fall in the rate of migration on cataphoresis. As a result of this they are phagocytosed. If the reduction in charge is interfered with, then phagocytosis is prevented in proportion to the amount of this interference. It has similarly been shown that the electric charge of the red cells in bird malaria is inversely proportional to the parasite count. The reduction in charge is the same in parasitized and non-parasitized cells in the same bird and this reduction is an important factor in inducing phagocytosis. It is persistent for months after the attack of malaria. The same factor of reduction in the charge of red cells has been found to be operative in mice infected with trypanosomes coincident with the appearance of antibodies in the blood as a result of the administration of Bayer 205.

Now if the reduction in charge is to be taken as a direct indication of the degree of immunity how is one to explain that a bird infected with one strain of malaria and therefore with a lowered charge in its red cells can be infected with another strain ?

In an effort to answer this question some interesting data were obtained. In the first place it has been demonstrated that the serum of immunized birds (i.e. a bird recovering from an attack) can reduce the electric charge of the red cells of a normal bird and in the second place that this action is a non-specific one, for the serum of an immunized bird can reduce the charge of normal mouse cells. The effect therefore can clearly be put down to a non-specific property possessed by the immune serum. The next problem was to determine what constituent of the serum possessed this property. It was first shown that

there was a definite correlation between the cataphoretic velocity of the red cells and the phagocytosis-promoting effect of the globulin fractions of the serum. The effect was therefore tried of sensitizing bacteria by contact with the albumen, pseudoglobulin and euglobulin fractions respectively of normal horse serum and then submitting the bacteria suspended in normal saline to cataphoresis. The three fractions were found all to have a charge-reducing effect, that of euglobulin being the greatest.

The phenomenon we have been considering may now be summarized as follows.

During the course of an attack of bird malaria changes in the electric charge of the red cells take place, the changes being exhibited to a like degree by parasitized and unparasitized cells. By the time the bird shows a good immunity response as evidenced by great destruction of parasites the negative charge of the red cells has been greatly reduced but, when the parasites continue to increase steadily the charge is substantially the same as that in the cells of a normal bird. The reduction effect is a non-specific property of the immune serum and is chiefly brought about by an increase in the euglobulin fraction.

Further work has shown that various other reactions more or less closely connected with immunity, appear to be dependent on the electrical charge of the cells concerned. Such reactions are serum hæmolysis, the adhesion phenomenon, non-specific protein shock effects, complement fixation, precipitation, and agglutination. The mechanism of the resistance of mammals carrying a low grade infection with malarial parasites to superinfection with the same strain appears to be similar to that described in bird malaria and there is no time further to discuss the subject. It should be mentioned, however, that in the case of a very virulent parasite, such as *P. knowlesi,* it is sometimes possible to produce superinfection involving death of the inoculated animal. This appears to be largely a matter of dosage.

Leishmaniasis.

I am afraid the time at my disposal will not allow me to treat this group of diseases with the fullness it deserves for it is one of the few protozoal infections which appear to confer a lasting immunity. Leishmaniasis takes two forms, visceral and cutaneous.

Visceral Leishmaniasis.

Kala-azar is a disease widely prevalent in the old world and it has recently been recorded from South America. Unlike malaria the areas of endemicity are usually pretty sharply marked. I need not go into the question of how it is transmitted because this is a question still in dispute.

The main pathological characteristic of kala-azar is that it is essentially a disease of the reticulo-endothelial system and of this system only. No other cells of the body are affected. In making this statement I am not sure if I am correct in calling it a disease of the cells of the reticulo-endothelial system because the parasite-macrophage complex is quite different to that seen in diseases such as malaria where the ingested parasites are destroyed. In kala-azar the parasites are not destroyed when phagocytosed but, instead, in the process actually gain their natural habitat in the vertebrate host. The anomalous situation arises that the invader makes a habitation of the defences of the host. We have seen the enormous importance of the reticulo-endothelial system in the defence mechanism of the body. When this system, by increased activity and proliferation due to the invading leishmania, thereby merely supplies greater facilities and room for the invader to increase in numbers it is not surprising that kala-azar is a very fatal disease. Is there, then, no defence mechanism whatever against *Leishmania donovani*, the cause of kala-azar? The fact that recoveries from the disease do occur is proof that there is but what the actual defence mechanism is has not been sufficiently studied. There is, however, no reason to suppose that it differs essentially from that in other diseases. What I have said about the use the parasites make of the reticulo-endothelial system would appear to rule it out as a defence mechanism. This, however, is not entirely the case. The majority of the parasites are seen to inhabit the macrophages and they appear able to resist lysis by these cells. Whether they can also resist the lytic action of the polymorphonuclear cells is less certain. When seen in these cells they often appear to be in process of disintegration and it seems that the polymorphonuclears are not, as are the macrophages, a suitable habitat for the leishmania.

Another defence mechanism also, which we have previously dealt with is more markedly active in kala-azar than in any other known disease. We have seen that there is a probability that a reduction in the charge of cells is possibly an essential preliminary in many of the mechanisms of defence and this reduction in charge of the red cells is more pronounced in kala-azar than in any other disease investigated from this point of view. This is accounted for, or at least correlated with, a very marked increase in the proportion of euglobulin in the serum. So great is the reduction in charge in kala-azar that, even with a pressure of 200 volts the red cells remain almost stationary.

I have mentioned the fact that cases recovered from a leishmanial affection, such as kala-azar, acquire a very prolonged, if not life-long immunity. What is this due to since it is not usual in the case of protozoal diseases?

Some recent work may throw light on this. It has been shown that recovered cases of kala-azar at a later stage sometimes develop a skin condition called dermal leishmanoid in which leishmania are present in the skin. The condition is extremely difficult to treat as the parasites in this situation seem almost immune from the assaults of any form of therapy. Such cases are able to harbour the parasites for many years in the skin. Now the number of cases showing these lesions is comparatively small, but it is more than a possibility that there are much larger numbers which, although they harbour parasites in the skin, show no appreciable lesions. It is not impossible that after recovery from the clinical diseases the vast majority of cases continue to harbour parasites in small numbers in the skin and that the continued presence of these keeps alive a defence mechanism which will remain operative as long as any parasites remain. The fact that some cases show an actual skin disease does not mean that this is a necessary concomitant of the infestation of the skin; they are probably only the exceptions. In this connection, it has been demonstrated that infected hamsters contain large numbers of parasites in the skin yet the latter is normal in appearance. Similarly in canine leishmaniasis parasites can always be demonstrated in the skin, even when this appears normal.

Much more might be said on kala-azar but it would be at the expense of some other conditions which I should mention and I must pass on to

Dermal Leishmaniasis (Oriental Sore).

Much that has been said of kala-azar applies to dermal leishmaniasis, the chief difference being that the latter is supposed to be a purely local condition. That it is not always so there is evidence to show but there is no time to go into this question. Here, as in kala-azar, a life-long immunity seems to follow cure. The parasites of kala-azar and of oriental sore are practically indistinguishable morphologically and it is curious that their effects and their response to the immune mechanisms of the body should be so different. Why one should give rise to a generalized and fatal infection while the other should remain a localized infection is quite obscure and I am afraid I must leave the problem there, but it is one well worth investigation.

Piroplasmosis.

The group of parasites giving rise to the diseases which may be grouped under this general term comes under the suborder *Piroplasmidea* containing the families *Babesiidae* and *Theileriidae.*

These diseases are of enormous importance to stock affecting, as they do, cattle, horses, dogs, etc., and causing great pecuniary losses in most parts of the world. The general course of events in infections with *Babesia* is for parasites to appear in the blood after a short incubation period. These increase rapidly until a very heavy infection is present. The disease may now kill the animal or it may recover clinically and the parasites may become so few as not to be demonstrable microscopically. The blood, however, remains infective and, if enough is inoculated into a susceptible animal, will reproduce the disease. This means that a minimum number of parasites is still in the circulation and is analogous to the case of birds in the latent stage of bird malaria. The same effect can be produced by partial cure of the animals by the use of drugs such as trypan blue. This principle has been widely applied as a practical measure in the safeguarding of domesticated animals in Africa against diseases due to both the *Piroplasmidea* and the *Trypanosomes.* The animals are infected with the strain of parasite in question, preferably with a strain in its latent stage, and are subsequently treated with a specific drug. This prevents a fatal termination of the infection but leaves the animal with a latent low grade infection which prevents subsequent superinfection.

Animals so rendered immune, either naturally or by drugs, are immune only to the strain originally causing the infection for they can be infected with strains of the same species from other localities. Thus a latent infection of *B. canis* in France will not protect a dog from the North African strain of the same species.

The immunity is not complete in all cases and it has been stated that in some cases a superinfection with the same strain may be imposed on the original infection. The superinfection, however, is said not to be accompanied by the clinical signs of the original disease. It seems to me that it would be difficult in such an experiment to exclude the possibility that the appearance of parasites may have been due to a recrudescence of the original infection.

In the case of animals which have suffered and recovered from an attack of *Theileria parva* which causes East Coast fever it is found that they are immune for life. That this may be due to the persistence of a very low grade infection is not an impossibility.

The mechanism of immunity in the piroplasmoses has probably been studied less than in some of the other protozoa which we have considered but there is no reason to suppose that it is any different. The extraordinarily rapid disappearance of parasites in an infection of *B. canis* at a crisis is quite dramatic and seems to be too sudden to be caused by phagocytic action alone although this probably plays an important rôle in removing

the débris. As the disappearance of the parasites is accompanied by the disintegration of the red cells which contain them the sudden development of anæmia is easily explained. It is at this stage of the infection that the defensive mechanism is often overwhelmed and the dog dies. This fact could, of course, be differently interpreted as showing that the defensive mechanism was *too* powerful and by causing the simultaneous destruction of the innumerable parasites with their containing red cells brought about the death of the animals from anæmia or an acute toxæmia. The immunity in recovered dogs is certainly due to the persistence of a low grade infection but whether a dog which had completely recovered could be reinfected with the same strain is not certain, although this is stated to be the case.

Before I conclude my remarks on the various mechanisms of immunity I must mention one line of research which is yielding results of interest in bacteriology and may later be applicable to the study of protozoal immunity also. I refer to work on the specific carbohydrates of bacteria. I have no time to go into this question but the literature on the subject might repay your perusal.

Discussion.

In reviewing the account I have given of the various factors concerned in immunity against protozoal diseases I wish to sound one note of warning. In all the phenomena we have been dealing with we are concerned with biological interactions only a part of the causes of which are within our ken and under our control. In other words we are attempting to solve equations where many of the factors are unknown. In mathematics such an equation would be put down as insoluble and so we must not be surprised if things do not always work out according to theories based on incomplete data. In a consideration, however, of the phenomena which we have been studying two or three things seem to me to stand out as fairly evident.

One of these is the fact that the mechanisms at work are very similar to, if not identical with, those which are operative in immunity against bacterial diseases. This is evident when we consider the predominant rôle played in the mechanisms of immunity by the reticulo-endothelial system, using the word in its widest sense and taking into account both its direct and indirect effects, since it seems likely that it plays its part in all the defence mechanisms of the host except the purely mechanical barriers such as the skin. The fact that the same cells of the reticulo-endothelial system are involved in immune reactions no matter whether the invader is protozoan or bacterium or, in fact, any other foreign body, lends strength to the view that the defence mechanisms of the body are a unified

protective complex capable of reacting against any invader and that there is no necessity to postulate special defence mechanisms for bacteria, protozoa, or other foreign substance whatever. If there are any differences they appear to be only differences in degree.

Another point which stands out in this retrospect of work on immunity leads one along a fascinating bypath back into the remote past. In the account I have given I have mentioned, although I had not the time greatly to stress the point that the immunity against protozoal species is extraordinarily specific and this specificity is attached even to strains within a species. This is especially apparent in the case of protozoa as compared with bacteria and viruses because, although the latter may sometimes contain disease-producing species which contain types or strains each of which confers little or no immunity against its co-types, this is the rule with the protozoa. Thus one attack of enteric fever or of small-pox or yellow fever usually confers life-long immunity from *all* strains of the organisms which are the causes of these diseases but an attack of most protozoal diseases does not appear to do so. If we take the case of malaria we find the immunity conferred by one strain of a particular species is so specific that, while it protects against superinfection by the identical strain it will not prevent superinfection by another strain of the same species. In other words, a man getting B.T. malaria in Bombay may develop immunity to his particular strain but gets a severe attack of B.T. malaria when he visits Africa or even places much nearer. Now it would seem, on the face of it, that this sort of immunity was very little use to man, who habitually moves about, has done so for remote ages past and is likely to do so more and more in the future. What then is the explanation of the development of an immunity so specific as to be comparatively useless to the individual? On thinking over this problem it seems to me that one has to go a long way back into prehistory even to the remote past of the time when the prehuman creature which was to become man roamed his jungles in much the same way as some of the anthropoid apes now do. The gorilla appears to go about in family groups or at least comparatively small parties which have little or no communication with other groups. Troops of monkeys in the jungle have much the same habit. They keep to their own locality and there is little or no intercommunication between troops. Under such circumstances, it is probable that only one strain of a malarial species or at least a very limited number will be present in any one group. The members of this group will develop an immunity to that strain so that in time host and parasite will accommodate themselves to one another. This is the condition seen for instance in the case of *S. irus* and its parasite *P. knowlesi*. The monkey tolerates its infection without inconvenience and the

parasite does not kill its host. If, however, one inoculates *P. knowlesi* into another monkey such as *S. rhesus*, which has no immunity to it, the result is disastrous both to host and parasite. The latter rapidly kills its host and thereby commits suicide. In course of time when, from family life, man developed community life and migrations took place, the immunity developed against single strains of malaria would be unable to cope with a multitude of new strains and so the development of immunity would become more difficult and less complete. This would bring us by degrees to the conditions prevalent in hyperendemic areas in the tropics where it takes a child four years to develop any sort of efficient immunity even to the strains in its own locality. To carry this conception to its logical conclusion one may say that disease, if by this we mean a departure from immediate normality, is inevitable in nature because change is inevitable. There is no static condition in the universe so that complete and final adjustment to one's surroundings is never possible. A change in one cell of an organism must, on account of its interconnections with its environments, inevitably cause a ripple which will reach the confines of the universe, since no minutest particle of the latter is isolated but necessarily has its contacts.

It is needless for me to elaborate this thesis further as the meaning is sufficiently clear ; but it would appear that in casting off his old mode of life man, in his quest for the higher life, sacrificed certain advantages.

A third point which has emerged from our survey is the question as to why immunity lasts, in some cases for years or the whole life, after all clinical signs of disease are gone and parasites can no longer be demonstrated. In the cases we have especially considered, viz. trypanosomiasis, leishmaniasis, malaria, and piroplasmosis, the balance of evidence seems to me to be in favour of the hypothesis that immunity persists so long as there is a residual infection and that with the final disappearance of this there is a return of susceptibility to reinfection. In some cases, such as certain kinds of trypanosomiasis and piroplasmosis, we know that reinfection can occur. In malaria the same holds. In kala-azar, where a second attack is almost unknown, we have seen that a skin infection may persist for many years and this may keep the immunity at a level sufficient to prevent superinfection. In oriental sore this might appear less probable but the extent to which this is always a purely local condition is uncertain and cases are sometimes seen which seem to exhibit an infection carried to different parts of the skin by the blood and therefore, presumably, to other parts of the body.

The same phenomenon, of persistence of the infective agent, leading to immunity is seen in syphilis and in various virus diseases also and it is not impossible that it is one of the usual natural methods of maintaining an effective immunity.

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Section of Medical and Veterinary Research.

Abstracts.

NUTRITION.

1. Distribution of vitamin C in different parts of common Indian foodstuffs.

M. N. RUDRA, Patna.

Bacharach et al (Biochem. J., 28, 1038) as a result of the examination of oranges, tangerines, and lemons found that vitamin C was present in gradually diminishing amounts as one passes from the skin inward. A systematic investigation of a large number of foodstuffs including fruits, vegetables, and animal and marine foods was undertaken in this laboratory. The method employed was the well-known dichlorophenol indophenol titration suitably modified from the existing methods. It has been found that generally vitamin C is most abundant in skin and gradually diminishes as one goes inwards, thus confirming Bacharach's findings. There have been very few exceptions to this rule. Some of the findings are given below (vitamin C contents in mg. per g. of the foodstuff).

Patal (*Mimordica diorca*) ..	Skin—0·44 ; flesh—0·25 ; seeds—0·1 ; leaves—0·29.
Ninua (*Luffa ægyptica*) ..	Skin—0·20 ; flesh—0·04.
Kumra (*Cucurbita maxima*) ..	Skin—0·098 ; flesh—0·05 ; seeds—0·036 ; leaves—0·11.
Plantain (*Musa*)	Skin—0·092 ; flesh—0·099.
Banana (*Musa sapientum*) ..	Skin—0·062 ; flesh—0·052.
Pear (*Pyrus communis*) ..	Skin—0·072 ; flesh—0·016.

Animal foods gave the following results :—

Goat's flesh—0·066 ; liver—0·26 ; kidney—0·176 ; heart—0·077 ; bone-marrow—0·0888.

2. Vitamin B_2-deficiency in relation to cataract, anæmia, and depilation.

N. DAS, K. SEN, *and* B. C. GUHA, Calcutta.

A study has been carried out with young rats subsisting on a vitamin B_2-deficient diet to investigate the dietary factors concerned in the production of cataract, anæmia, and depilation. Lactoflavine has been found to have a definite hæmopoietic effect. The production of depilation has not been regular and cataract has not been observed in this batch of animals.

3. Comparative studies on the nutritive values of the cow's, goat's, buffalo's, and human milk.

N. DAS *and* B. C. GUHA, Calcutta.

Using young rats as the experimental subjects the growth-promoting effects of the different varieties of milk, as the sole sources of food, have been measured. The vitamin values of the different varieties of milk have also been determined.

PHYSIOLOGY.

4. Influence of sodium chloride on the viscosity of serum proteins.

R. N. Chopra and S. N. Mukherjee, Calcutta.

Viscosity of blood sera in presence of different concentrations of sodium chloride has been determined. The lowering observed with increasing concentration of the salt is very significant since a change in viscosity has a very great influence on the hydrostatic pressure of the circulation, in consequence of which the rates of transudation and exudation of tissue fluids are disturbed. From this an additional clue may be obtained as to why salt-free diets are prescribed in cases of œdema.

5. Physical properties of the blood plasma and the electrical charge of red blood cells after injection of cobra venom and Russel's viper venom in Monkeys.

R. N. Chopra, S. N. Mukherjee, and J. S. Chowhan, Calcutta.

Both surface tension and viscosity of plasma undergo changes when injections of cobra venom or Russel's viper venom are given to monkeys. Surface tension decreases while viscosity is found to increase. With small doses of cobra venom the effect becomes marked in two hours' time while the plasma practically regains its normal condition in twenty-four hours' time. With large doses, however, the normal condition is not reached even in course of twenty-four hours. With viper venom, on the other hand, action in two hours is not at all marked but that after twenty-four hours become prominent. The action of viper venom on the plasma, however, appears to be slower. Both these venoms are practically without action on the reaction or the buffer action of the plasma.

So far as the red cells are concerned their electric charge seems to be diminished by administration of cobra venom. This diminution runs continuous and there is no indication of recovery even after twenty-four hours. The action of Russel's viper venom seems to be different since a slight tendency towards increase of charge was observed.

6. Observations on sugar-content of normal urine and blood.

K. N. Bagchi and M. N. Rudra, Patna.

An attempt has been made to find out if there is any relation between the normal urine-sugar and normal blood-sugar. The method adopted for the estimation of normal urinary sugar was that of Kingsbury (*J. Biol. Chem.*, 75, 241) as modified by one of the authors (M. N. R.—*Pat. Jour. Med.*, 1935, 29). The blood sugar was determined by the Hagedorn and Jensen method. The subjects chosen for the experiments consisted of all classes of people. The samples of blood and urine were collected about two hours after midday meal. All the experiments were performed in duplicate. The following results were obtained (in milligrammes per 100 c.c. of urine and blood): Average sugar-content of normal urine and blood of all the cases of our series—84 and 103; among the Bengalees—83 and 103; among the Biharis—93 and 118; among the Oriyas—89 and 124. According to religion: Hindus—91 and 113; non-Hindus—88 and 103. According to diet: vegetarians—94 and 124; non-vegetarians—90 and 109 respectively. The maximum sugar-content of normal urine and blood was found to be 110 mg. and 142 mg. and the minimum 36 mg. and 88 mg. respectively. From our own observations and from those of other investigators in Europe and America it is found

that the sugar-content of normal urine is always lower than that of normal blood. By plotting the average sugar-content of normal urine and blood against average age we get two curves which run almost parallel.

7. Studies on the dimensions of erythrocytes of man.

HEMENDRANATH CHATTERJEE, Calcutta.

The modern classification of anæmias is based upon the variations in the size, the number and the volume of the red blood cells and the various indices derived from them.

One of the main criteria by which it is customary to divide anæmias into distinct groups is the diameter of the red corpuscle.

The different methods of measurement of the diameter of the red cell are discussed and it is shown how different specimens of moist and dry film preparations made from the identical puncture, give remarkably different readings, by each of the two well-known methods, viz. measurement of the diameter by the camera lucida and by the halometer.

The fallacies and the difficulties of the above methods are discussed and the results compared with those obtained by the volumetric method.

Stress is laid upon the estimation of the thickness of the red cell along with the diameter and the total volume of each individual corpuscle rather than the diameter alone.

8. A preliminary note on measurements of blood pressure.

J. C. GUPTA *and* P. C. MAHALANOBIS, Calcutta.

Measurements of blood pressure (systolic and diastolic) were taken with an aneroid manometer for over 800 male subjects (mainly Bengali) of various ages from about 7 years to about 63 years. Records were taken of the religion, caste, occupation, height, weight, and pulse rate of the subjects, and notes were kept of the diet and also of abnormal physical conditions or serious illness. The present paper gives a summary of the results by ages and castes and also the correlations between different factors of variation.

SEROLOGY.

9. Influence of antibody formation on the pseudoglobulin fraction of normal serum.

M. M. BISWAS, Calcutta.

Potentiometric titrations of diphtheria antitoxic serum, pseudoglobulin of normal serum, and egg-albumin have been made with varying concentrations of different acids and the titration curves drawn. The influence of antibody formation on the protein character of pseudoglobulin has been discussed from a comparative study of the curves. The titration curve of egg-albumin has been referred to as a standard of comparison. The object of such a study consists in finding out if any light can be thrown on the controversial problem of the actual determinant groups of an antibody by physico-chemical means.

10. The nature of the allergic reaction in tuberculosis.

M. B. SOPARKAR, Bombay.

It is a striking fact that tuberculin, which is relatively innocuous for normal animals, is highly toxic, even in minute doses, for tuberculous animals, in which it produces a characteristic reaction.

Several hypotheses have been advanced to explain the phenomenon but, in spite of extensive investigations on the subject, the mechanism has not been satisfactorily explained.

Certain experiments carried out to study the nature of the reaction have shown that when an extract obtained from the *healthy* skin of a tuberculous animal is mixed *in vitro* with old tuberculin and the mixture injected intradermally into a *normal* animal it produces a typical reaction resembling the usual tuberculin reaction obtained in an infected animal. A time factor was also observed in the interaction of the skin extract and tuberculin. Neither tuberculin itself nor the extract of the skin alone injected in the same animal produced any reaction.

The blood serum of a tuberculous animal when similarly mixed with tuberculin *in vitro* failed to produce any reaction, indicating that the causative agent of the reaction, whatever it be, is not present in the serum. Similarly a mixture of tuberculin with an extract made from the skin of a *healthy* animal likewise failed to give a reaction.

These experiments were carried out in bullocks and buffaloes in which the skin reactions are more definite and pronounced—especially so in the buffalo—than is usually the case with guinea-pigs which are generally employed in these experiments.

These results would seem to afford experimental support to the hypothesis based on the work of Maurice Nicolle and of Wolff-Eisner that there is present in the highly sensitized skin cells of the tuberculous animal a lytic product which, when brought in contact with tuberculin, produces a toxic substance which determines the local inflammatory reaction.

PATHOLOGY AND BACTERIOLOGY.

11. The respiratory mechanisms of *Staphylococcus albus* and *Staphylococcus aureus*.

N. DAS *and* B. C. GUHA, Calcutta.

The difference in pigmentation between *Staph. albus* and *Staph. aureus* led us to investigate the influence, if any, of the flavines on the respiration of the bacteria as measured with a Warburg micro-respirometer. Flavines have been found to have no effect on the respiration and the existence of a cyanide-stable respiratory system, which accounts for a fraction of the respiration, has been demonstrated. The period of cultivation of the bacteria has been found to affect the proportion of this cyanide-stable respiration to the total respiration.

12. An enquiry into the origin of non-pulmonary tuberculosis.

S. RAMAKRISHNAN *and* K. S. SANJIVI, Madras.

The present position regarding bovine infection in India is summarized. 234 specimens have been examined from suspected extra-pulmonary cases microscopically and by animal inoculation.

In one case the infection was probably bovine; in another it was doubtful. Eight strains were definitely human in type.

Four specimens showed acid-fast bacilli non-pathogenic to the guinea-pig. In eight definitely tuberculous cases, the material examined was negative both on smear and animal inoculation.

Admittedly the cases reported are few; yet they seem to emphasize the necessity for conducting such an investigation.

13. An easy method of transplanting tubercle bacilli directly from solid to liquid culture media.

M. B. SOPARKAR, Bombay.

The growth of tubercle bacilli on liquid media occurs only on the surface and the seed used for inoculating the media must, therefore, remain floating; if it is submerged no growth will occur. Successful surface transplantation is comparatively easily accomplished from one broth culture to another; and in the case of the human type of the bacillus, even from solid media, by depositing a few dry scaly fragments of growth on the surface of the broth. This however is difficult with moist growth such as of the bovine tubercle bacillus or the slimy growth of the avian bacillus. An easy method has been developed by which any culture, whether dry, moist or slimy can be transplanted directly from solid media on to the surface of fluid media on which growth begins to appear and spread. The method has been in use for some years and has been found highly satisfactory in obtaining a large number of broth cultures of tubercle bacilli of all types and of other surface-growing organisms at any time directly from solid media.

14. The rôle of malaria in the causation of cirrhosis of the liver—an investigation.

T. S. TIRUMURTI *and* M. V. RADHAKRISHNA RAO, Vizagapatam.

In a paper read in the Medical and Veterinary section of the Indian Science Congress last year we pointed out (vide *Jour. Indian Medl. Association*, April, 1935) that the co-incidence of malaria and cirrhosis of the liver in India has given rise to differences of opinion regarding the rôle of the former in the causation of the latter. A critical investigation of the morbid histological changes in chronic malarial livers, by the application of different staining methods, including the silver impregnation of the reticulum, has confirmed our previous experience that malaria *per se* is not a direct cause of cirrhosis of the liver.

15. Pneumonia in foals due to *Corynebacterium equi*.

V. R. RAJAGOPALAN, Muktesar.

A particular form of pneumonia is known to occur with some frequency in certain breeding studs in the Punjab, and the etiology of this condition, which was thought to be identical with that described by Magnusson in Sweden, has been under investigation for some time.

The infection is generally confined to foals about one to two months old and, occasionally, symptoms of joint-ill may be seen in addition to those of pneumonia. The mortality is high. *Post-mortem* examination reveals large abscess cavities in the lungs and the mediastinal glands.

Corynebacterium equi, which appears to be the causal agent, can be recovered in nearly every case in pure culture from the abscesses in the lungs and mediastinal glands, as well as from the fæces, sometimes from the heart-blood and, rarely, from the joint fluid of naturally as well as artificially infected cases. The cultural and biochemical characters of this organism are described.

It has been possible to reproduce the typical symptoms of the disease by an intranasal douche of a saline suspension of the organism. Age, as in natural incidence, appears to be the chief factor in the artificial reproduction of the disease.

16. Is cholera kidney a form of nephrosis ?

D. N. BANERJEE, Calcutta.

The nephrologists Munk (1918) and Elwyn (1926) are definitely of opinion that cholera kidney is a form of nephrosis. Further, workers on tropical diseases throughout the world—Rogers (1921, 1922), MacCullum (1932), Krause (1924), Fuji (1928), Ishihara (1912), and others although they have not definitely used the word 'nephrosis' show from their description of the renal condition in cholera that they actually mean what is generally called by the term nephrosis.

A comparison of the pathological, biochemical, and clinical features found in nephrosis with those found in cholera, definitely indicates that cholera presents gross features which are quite distinct from those of nephrosis, particularly in the following aspects: histological changes in the glomeruli, retention of nitrogenous waste products, course, œdema, and uræmia.

17. The proteus group.

S. R. PANDIT, Madras.

An examination has been made of the cultural, biochemical, and serological reactions of 25 proteus strains, most of which were isolated from fæces and urine and including X_{19} and Kingsbury strains obtained from other laboratories. Six agglutinating rabbit sera have been prepared and the strains tested against them in straight agglutinations with H and O suspensions and with homologous suspensions after carrying out absorption tests with the different strains. All the strains gave 'swarming'. The importance of maltose fermentation as a basis for classification has been confirmed. Eight strains, inclusive of X_{19} strains, which ferment maltose, also produce indol, do not liquefy serum, and with two exceptions, ferment saccharose and salicin readily. Seven strains do not agglutinate with any of the sera or agglutinate to a negligible titre. There is no correlation between fermentation and serological reactions. By agglutination and absorption of H and O agglutinins, six strains, including X_{19} strains, fall into one serological group, four others into a second and the two Kingsbury strains into a third group. While the O antigen is more specific there is a greater community of H antigen. X_{19} and Kingsbury strains have been compared.

PHARMACOLOGY AND THERAPEUTICS.

18. Treatment and prophylaxis of cholera in the settlement of Karaikal.

J. LE. ROUZIE, Indore.

The Settlement of Karaikal, situated on the Coromandel Coast to the east of Tanjore, has the same epidemic variations as the Madras Presidency. The outburst during the winter 1934-35 attacked 175 cases of which 77 died, thus showing 44% of deaths.

Treatment :—One part of the patients was treated by orthodox methods: adrenaline, cardiac tonics, hypertonic saline, kaolin 'per os': 57 cases, 21 deaths, mortality 36·8%.

Another part had the same treatment in addition to bacteriophage of Pasteur Institute of Shillong: 89 cases, 27 deaths, mortality 30·3%.

29 cases were moribund and died before receiving treatment.

Prophylaxis:—While the epidemic was proceeding rapidly a portion of the population was vaccinated.

7,328 persons were vaccinated at one time by the anti cholera vaccine of Guindy Institute, Madras, without any notable incident.

Among the vaccinated, 3 had cholera two or four days later, but in one exceptional case it appeared 18 days after the vaccination. This was fatal.

In short, excellent results with anti-cholera vaccine of Guindy, Madras, and with bacteriophage of Shillong were obtained.

19. Sodium lactate in the prevention and treatment of cholera acidosis.

D. N. Banerjee *and* S. K. Datta, Calcutta.

That acidosis occurs in almost every case of cholera, becoming severe in many cases, is admitted on all hands. Sodium bicarbonate has been in use since the time of Sellards for the purpose of prevention and treatment of acidosis in cholera. Although sodium bicarbonate serves the purpose best, it has its disadvantages, which are mainly as follows: sudden increase in the numerator of the bicarbonate-carbonic acid ratio in blood; the fact that it can be given only by the intravenous route which is not often possible in the case of children, and the fact that it changes into carbonate on boiling for sterilization, etc.

On the other hand, sodium lactate has been found to act in a similar way on account of its property of being completely metabolized in 2 hours with conversion of the lactate ion into glucose, by liberating sodium ion practically quantitatively which combines with excess of carbonic acid to form a rapid supply of bicarbonates, by being stable can be kept over long periods and can be sterilized easily by boiling, and by its being non-irritating for subcutaneous injections.

With these points in view we have been using sodium lactate for the last three years with gratifying results. The CO_2-combining power of plasma shows considerable improvement in all cases after injection of molar solution of sodium *r*-lactate.

20. Action of cobra venom on tissue cells in vitro.

R. N. Chopra *and* N. N. Das, Calcutta.

While working on the growth of tissue cells *in vitro*, we tried to observe the action of different substances on their growth. Cobra venom in dilutions of 1/1000 stopped the growth of these cells, and fatty degeneration took place after first passage. The choroid coat of the retina from chick embryo was mostly used as an explant. This tissue grows vigorously in the chick plasma and chick embryo extract as media. Different dilutions of the venom were tried on the explants and it was observed that the dilution of 1 in 500,000 produced a marked acceleration in growth. About sixty different explants were tried and as many as 75 per cent. responded with this effect.

21. Hæmorrhagic action of snake venoms on the capillaries of chick embryo.

R. N. Chopra, J. S. Chowhan, *and* N. N. Das, Calcutta.

Persons bitten by vipers and particularly *Echis carinata* (Phoorsa) sometimes get severe hæmorrhages from the site of the bite, nose, gums,

mouth, eyes, skin and sometimes in the interstitial spaces. The Echis venom is said to be eight times as hæmorrhagic as the Daboia venom (*Vipera russellii*). This action was studied on the embryonic blood vessels of the chicken.

Freshly laid hens' eggs were incubated till the embryonic blood vessels were well developed. When the fine blood vessels and capillaries are exposed and focussed to a magnification of 50 diameters the circulation of blood in the vessels is clearly seen. A few drops of the Echis venom in different concentration dissolved in normal saline, were added to a series of eggs thus prepared and the results noted. Within 1-2 minutes the blood vessels were found to develop irregular knob-like dilatations in their channels. After 5–10 minutes the vessels went on dilating and were finally ruptured. Photomicrographs of blood vessels were taken before and after the addition of the venom. Russell's viper venom showed action similar to the Echis venom but it was less powerful. It may be possible to make quantitative estimation of the hæmorrhagin contents of snake venoms by this method.

22. Pharmacological action of camphor derivatives and their uses as a cardiac stimulant.

R. N. Chopra, J. S. Chowhan, *and* N. De, Calcutta.

Camphor has been widely reputed as a circulatory stimulant, but recently there has arisen a diversity of opinion regarding its toxicity and therapeutic efficiency. It has actually been reported as a depressant by some and as a stimulant by others. Pharmacological action of a series of water soluble sodium salts of isonitroso camphors was studied on the heart and circulation of cats and frogs. A one per cent. solution in saline of these compounds produced a rapid and transitory fall of blood pressure in case of *d* isomer and less so with *l* and *l*. In isolated kitten's heart, perfused with 1 in 50,000 to 1 in 1,000,000 the frequency was decreased but the tone was increased. This stimulation was more marked with the *d* compound less with *dl* and nil with *l*. The coronary flow was reduced. In perfused frog's heart delayed but mild stimulant action was observed with *d* compounds. Intrahepatic injections in frogs produced appreciable stimulant action followed later by periodic heart block which was more marked with this *d* isomer. Myocardiographic records showed no changes with ordinary doses but larger doses produced dilatation and irregularity in rhythm.

23. Some inorganic preparations of indigenous medicine, *Samudra phena* and *Raupya bhasma*.

S. Ghosh, J. C. Gupta, *and* A. T. Dutt, Calcutta.

Samudra phena.—This substance is believed to be derived from the sea foams (whence its name) but it is really the scale or bone of a sea-fish and is collected from the sea coasts. A well-known Ayurvedic physician recommended its internal use as a good source of organic calcium and sent it to us for complete analysis. The dose is from 5 to 15 grains. The substance was found as an oval-shaped, hard, porous, friable white mass. On quantitative analysis, it was found to contain lime (CaO) 49·72%, carbon dioxide 38·56%, and small quantities of chlorides, iron, alumina, phosphates, silica, and nitrogenous matter. The calcium was present chiefly combined with CO_2 as calcium carbonate and only a small portion of the calcium was found in organic combination.

Raupya bhasma.—This substance is used in the Ayurvedic medicine and is believed to be a cooling tonic remedy having special soothing action on the nervous system and mucous surfaces. It is often used in combination with other metallic preparations such as tin, iron or gold.

It has been used with success in cases of neuritis and neuralgia. It is prepared by calcining silver with mercury and sulphur. The dose is from 1 to 3 grains. The material supplied was a greyish-black amorphous powder with a slightly metallic taste. It was subjected to complete qualitative and quantitative analysis and found to contain about 69·5% of silver, 15·2% of sulphur, 10·1% of iron and alumina together with some copper, lime, phosphate, moisture and traces of other constituents.

The effects produced by these substances on the human organism are under investigation.

PUBLIC HEALTH AND GENERAL.

24. The composting of habitation wastes—experiences of a year's working of an installation on the Indore system at Secunderabad.

A. E. CAMPBELL, Secunderabad.

The origin and development of the work are outlined and the topographical, administrative, and sanitary conditions affecting its establishment described.

The progress of the experiment is described from its inception and mention is made of the various problems encountered which included those of an engineering, labour, and sanitary nature.

The process of charging the trenches and turning the compost are next dealt with and the various experimental modifications which were tried out are mentioned.

The sanitary aspects of the developmental stages are described. Special reference is made to the presence and progress of fly-breeding which is of special local sanitary importance and also to the production of offensive odours during certain stages of the process.

The present working of the process is next dealt with in the installation as finally completed and using the method of working found to be most suitable. Particulars are given regarding the supply of night soil and rubbish, the population served, results of analysis of samples of compost produced, and sales to the public.

In drawing conclusions it is pointed out that this paper is written primarily from a sanitary point of view and treats considerations of economy and the production of a useful manure as secondary, although also of great importance.

It is concluded that the process is one which recommends itself for local adoption and extension, provided it be accepted that at times temporary cessation may be necessary.

25. Utility of antiseptics and coagulants in composting habitation wastes.

M. A. NICHOLSON *and* S. C. CHAKRABARTY, Indore.

The Indore process of disposal of habitation wastes by composting permits of the hatching of some fly larvæ on the cooler surfaces of heaps freshly charged and sometimes after the first turn, though never after the second. Such larvæ cannot become flies if the prescribed turns are given.

In an attempt to guard against the escape of larvæ from the heaps and to cover departures from the process routine several antiseptics and coagulants were tested.

A 1% solution of copper sulphate spray controlled larvæ well in dry weather and partially in wet, provided that the process technique was followed. Otherwise, there was no effect. Hence the only benefit to be derived from this refinement lies in fewer chance escapes of larvæ to shelter in wall crevices in improvised installations, but usually birds are found to deal with such escapes.

26. The experiences of Alwar city in the working of the Indore process for the disposal of habitation wastes by composting.

CHIRONJILAL NAGAR, Indore.

The Indore process was adopted in October, 1934, by the Alwar Municipality to serve an area with a population of 17,000. No difficulty was found in working, and it will become profitable when the whole of the manure is sold at a price of more than annas 7 a ton. The compost was favourably reported on by users and no difficulty is anticipated in selling the full output when cultivators become aware of its cheapness and efficacy.

Details of the costs, quantities, labour, design of the installation, manurial value and sales are given.

27. The treatment of enlargement of the prostate by a novel method.

J. R. ROBERTS.

That tho enucleation of the prostate is a formidable operation for an old man, and is only done in selected cases leaving large numbers to drag on to a miserable death.

The advocacy of the method of injection of a fibrosing or resolving fluid into the substance of the prostate.

Description of the technique and solutions used.

The use in cases of 'Prostatic bar'; mention of cases of atonic bladders.

Treatment of cases of posterior urethritis by injection of the prostate.

Its employment in cases of infective ovaritis.

PARASITOLOGY.

28. Atmospheric temperature and humidity with reference to transmission of malaria by *Anopheles stephensi.*

R. KNOWLES *and* B. C. BASU, Calcutta.

During the last four years the Malaria Transmission Enquiry under the Indian Research Fund Association has been working to determine for the different transmitting species of Indian Anophelines, what are the limits of atmospheric temperature and humidity between which transmission of malaria will take place. The enquiry started with *Anopheles stephensi.* With regard to the control of temperature and humidity, we use an air-conditioning cabinet in which the temperature can be set to any point between 50°F. and 100°F. and the relative humidity adjusted to any point between 50 and 100 per cent.

Batches of clean laboratory bred *Anopheles stephensi* were fed on gametocyte-carriers of three species of malaria (*P. falciparum*, *P. vivax* and *P. malariæ*) and immediately after feeding were put in Barraud cages and exposed to 36 different combinations of temperature and

humidity in the air-conditioning cabinet. From time to time they have been examined by dissection as well as sections for gut and gland infections. In each case a gametocyte count was carried out on the donor immediately before feeding the mosquitoes on him with a view to find out the minimum number of gametocytes in the blood which will be infective to mosquitoes.

The whole mass of data is now under investigation, but already the following findings of interest emerge :—

(i) Both temperature and relative humidity play important parts in the transmission of malaria with *Anopheles stephensi.*

(ii) At 50°F. and all humidities between 50 and 100 per cent. no infection was obtained with any species. Controls of the above experiments at room temperature were made and showed salivary and gut infection with *P. vivax* and *P. falciparum* and gut infection with *P. malariæ.*

(iii) At 100°F. and all relative humidities between 50 and 100 per cent. no transmission is possible with *A. stephensi* as they do not survive till they are infective.

(iv) Infection occurs with *P. falciparum* at ranges between 70°F. to 90°F. and humidities between 50 and 100 per cent. and salivary infection is seen frequently. At 60°F. and 60 per cent. relative humidity a very poor percentage of mosquitoes was infected but at the same temperature and other humidities no infection was found.

(v) Infection with *P. vivax* occurs at 60°F. to 90°F. and generally with high relative humidities between 70 and 100 per cent. and the heaviest salivary gland infections were obtained at 80°F.

(vi) With *P. malariæ* we have failed so far to obtain salivary gland infection. Gut infection with this species has been seen at temperatures between 60°F. and 90°F., the heaviest being observed at 70°F. Generally heavy infection was found in higher humidities.

(vii) The maturity and numerical strength of the gametocytes in the donor's blood play an important rôle in infectivity of mosquitoes.

(viii) It would appear that an infected mosquito is very different from an infective mosquito. In some of the fed mosquitoes (especially with *P. falciparum* infections) oocysts packed with sporozoites have been found developing towards the lumen of the mid gut; such oocysts would rupture into the gut and the mosquitoes concerned could not be infective.

(ix) Under these experimental conditions the percentage of survivors of *A. stephensi* was found to be longest in low temperatures and higher humidities.

The paper will be illustrated with Charts and Lantern slides and the previous literature on the subject will be discussed.

29. The viability of the 'infective' forms of the larvæ of *Wuchereria bancrofti* when freed from the mosquito host.

K. P. Menon *and* P. V. Seetharama Iyer, Guindy.

Mosquitoes infected with the larvæ of *W. bancrofti* become infective in about 12 days. These infective forms are able to live in saline and water for a considerable time. Their longevity outside the mosquito in various fluids of known strength was therefore ascertained.

These infective larvæ were able to live in plain tap water for 4½ to 6½ hours. It was also noticed that they could live in 0·2 per cent. hydrochloric acid with different concentrations of starch and egg albumen for 20 to 45 minutes.

The possibility of these infective larvæ remaining alive in natural waters sufficiently long to warrant the inference that human hosts could contract the infection through drinking water is indicated. The possibility that these larvæ when swallowed could resist the action of the acid gastric contents is also pointed out.

These observations are reported in the hope that they may lead to further investigation along similar lines with a view to settling whether filarial infection with *W. bancrofti* may be contracted by means other than the bite of the mosquito.

30. The cultivation of vaccinia virus on the chorio-allantoic membrane of the chick embryo.

C. G. PANDIT, R. S. RAO, *and* H. E. SHORTT, Guindy.

Vaccinia virus has been successfully cultivated on the chorio-allantoic membrane of the chick embryo. For the initial seed clove-oil treated calf-lymph (dermal strain) was used.

Up to the date of writing 64 passages have been made. During the earlier part of this work, the technique described by Stevenson and Butler (*Lancet*, July 29th, 1933, page 228) was employed, but latterly the improved technique of Goodpasture and Buddingh (*American Journal of Hygiene*, 1935, 21. 2. 319) which involves the use of a dental drill has been adopted.

At any stage of this work the potency of the cultured virus never reached the high titre attained by the routine calf-lymph of this laboratory. It maintained a general level such as to give vesiculation in a dilution of about 1 : 100, but in some passages dropped to 1 : 10 and in others rose to 1 : 500, while the calf-lymph regularly gives a titre of over 1 : 1500. The tests for potency were, however, done on calves while almost all other workers on this subject used rabbits for the test. Experience here is that the rabbits are more susceptible to the virus than calves and so can be expected to show a higher titre than calves. The storage qualities also do not compare favourably with those of calf-lymph.

Experiments have been carried out to discover if any change in the direction of neurotropism has taken place in the dermal virus as a result of serial passages in eggs. Results show that the cultured virus has not acquired neurotropic properties.

31. Stone-production and urine volume.

S. RANGANATHAN, Coonoor.

During the course of a long series of experiments on 'stone-production' in albino rats, a definite correlation has been observed between the 'stone-producing' potency of various diets and the volume of urine voided. For example, rats given white bread 97 parts, dried yeast 3 parts, water ad lib. and ·3 gramme CaO daily, develop stone with great regularity within a period of two months. The addition of milk or sodium phosphate to this diet eliminates stone or materially reduces its frequency and at the same time the volume of urine voided is greatly increased.

32. The chemical analysis of Indian foodstuffs.

S. RANGANATHAN, Coonoor.

A systematic survey of the chemical content of Indian foodstuffs is being undertaken at Coonoor, most attention being given to the elements of greatest practical importance in human dietetics—calcium, phosphorus, and iron. Although the survey is at present only in its early stages, some interesting observations have been made. Certain leafy vegetables—e.g. amaranth and Drumstick leaves—which are widely used by the poor, are very rich in iron and moderately rich in calcium and phosphorus. Indian tubers are, in general, a poor source of these elements. In contradistinction to the leafy vegetables, pulses contain more phosphorus than calcium. Goats' milk has been found richer in calcium and phosphorus than cows' milk; the latter, however, contains more iron.

DERMATOLOGY.

33. Age incidence of Leucoderma.

G. Panja, Calcutta.

The age-incidence of leucoderma in 700 cases has been analysed and recorded in graphs. There is an increase in the frequency of the disease up to the age of 15 years, the highest incidence being before puberty followed by a fall during puberty. There is a rise in the incidence again after puberty followed by a gradual fall until old age. A possible cause of the disease is suggested.

34. Primary pyocyanea infection of the skin.

G. Panja, Calcutta.

Pseudomonas pyocyanea can give rise to primary dermatitis characterised by oedema, formation of papules, vesicles and ulcers and marked watery secretion. An autogenous vaccine-therapy is useful in the treatment of such conditions.

35. Infantile Eczema.

G. Panja, Calcutta.

Infantile eczema is a distinct clinical entity. It is caused mainly by an internal sensitizing antigen which is either endogenous in the bowel or exogenous in the food, particularly cow's milk, or both. A large number of cases give positive skin test to milk. The disease is non-infectious.

Two types of eczema are commonly seen namely seborrhoeic and pure infantile or allergic. The latter variety is more frequent in this country and is very resistant to treatment. Secondary infections are common in this disease. Symptoms, differential diagnosis and prognosis are described. Photographs of cases and methods of treatment are given.

Section of Physiology.

President :—Dr. W. Burridge, D.M., M.A., F.N.I.

Presidential Address.

SOME FUTURE LINES OF ADVANCE IN PHYSIOLOGY AND MEDICINE.

It would seem fit and proper in this, the first presidential address of this new section of the Indian Science Congress Association, to indicate some probable future developments in our own branch of scientific study. The developments to which I refer wait on the attainment by physiologists in particular, and medical research workers in general, of knowledge of the laws that govern the stimulation of rhythmically active structures to greater activity, and of their behaviour when so stimulated, as well as on a more lively appreciation of the fact that living tissues are also colloidal systems. These developments wait because of the great attention paid by physiologists in the past and to-day to the phenomena attendant on the electrical excitation to activity of the members of the frog's muscle-nerve preparation.

The science of physiology is founded on the phenomena presented by isolated muscle and nerve. Physiologists have believed, with all that firmness with which the theologian holds to an a. ticle of faith, that all the fundamental properties of living matter are present and can be studied in the frog's muscle-nerve preparation. This belief has led them to build their science on three fundamental theories, which are: (1) that natural stimulation, such as that of the eye by light or the ear by sound, is a process precisely similar to that of exciting an isolated muscle or nerve to activity by electric currents ; (2) that all organs of the body remain quiescent until excited to activity by a stimulus ; (3) that the process of stimulation is akin to an explosive action. This view of stimulation is based on the belief that electric currents excite activity by giving a shock or commotion to unstable compounds called excitable substances which then undergo a process akin to an explosion and so release energy.

These three theories, either individually or jointly, are incorporated into all other theories which attempt to explain how any organ of the body behaves, If, then, any one of them be invalid, every theory based on it must also be invalid. And if all three theories be invalid, very little of our science is left. The facts will remain, of course, but they will require to be regrouped into quite different combinations or theories, and that means the development of a different science.

It is therefore germane to our subject to point out that there never was a time when anybody advanced any scientific proof of any of these fundamental theories. They are to be regarded instead as the fundamental presumptions with which scientists have furnished themselves before making observations. There is no doubt, for example, that the stimulating action of light on the eye is a natural stimulation. Consequently, if we wish to study natural stimulation, the eye should present all necessary material for research thereon. No observer of retinal stimulation, however, has ever thus studied natural stimulation, simply because he has taken it for granted that the stimulating action of light on the retina is exactly the same as the action of electric currents on isolated muscle or nerve. And so long as that belief is held the problem will be to advance an explanation of what is observed through eyes in terms of what is known about the actions of electric currents on isolated muscle or nerve.

There was similarly never a time when any proof was advanced that all organs of the body are quiescent until excited by a stimulus. It has instead been taken for granted that they are because the members of the frog's muscle-nerve preparation are; for those tissue constitute the physiological standards of reference.

These fundamental presumptions of our science were established about a century ago, and have been in existence long enough to have become part and parcel of the automatic thinking of the average physiologist. They further so form the foundations of our science that modern scientific workers may aptly be compared with builders and decorators of the building erected thereon. A noteworthy contribution to the science may then be equally aptly compared with the addition of a storey to the building, or with the decoration of its main assembly hall. Any such builder or decorator could further be naturally expected to take pride in his achievement. Any suggestion that the foundations are faulty would equally naturally therefore be unwelcome. So long as scientists are human, then, we cannot expect any enthusiasm for the evidence of fact which demonstrates that the foundations of our science are faulty, because it implies the dismantling of the old building and re-erecting on new foundations. And even after the new facts are sufficiently assimilated to lead to some doubt about the old foundations, we may well at first find enthusiasm for extending them down to a bedrock which ought to exist below shifting sands rather than for schemes for building anew.

Since in the course of this address references will frequently be made to quiescent and rhythmical tissues respectively, it may now be pointed out, for the benefit of those who are not physiologists, that a loaded machine gun provides the analogue of a living structure which remains inactive until excited to activity by an external agent which physiologists call the sti-

mulus. A petrol motor ticking over, on the other hand, forms a good example of a rhythmically active structure in that it regularly repeats a definite cycle of events over and over again. This machine, in physiological language, is stimulated to greater activity through the application of pressure to its accelerator pedal.

It will be part of the argument that physiologists through their attention to isolated muscle and nerve have been equivalent to machine-gun specialists firmly believing that all the principles of all machines are present in the machine-gun. The corollary to such a belief, of course, is that the more one knows about the working of machine guns the more one knows about the working of *all* other machines. Consequently after one has found through carefully conducted experiments that the velocity of the bullet is independent of the pressure exerted on the trigger, whereas the speed of a motor varies with the pressure on its trigger or accelerator pedal, it would become necessary for our imaginary machine-gun specialist to put forward a special hypothesis to bring the working of a motor into agreement with the working of a machine-gun. A possible solution of the difficulty, it may be noted, would be a fractionation hypothesis; one could imagine that the motor was a machine with a thousand cylinders or barrels, and that increasing pressure on its trigger brought an ever greater fraction of the total number of cylinders into action.

Before dismissing such an hypothesis as being hopelessly fantastic, one should realize that everything is known about the structure and functions of the machines which men themselves construct and that there is much to be learnt about the structure and functions of living tissues. To begin to appreciate the difficulties which face physiologists, one would require to imagine a machine-gun and a motor built somehow or other to look both externally like spheres! After the imagination has been sufficiently staggered by trying to do this, a reasonable idea will be obtained of the difficulties which face the physiologists when he deals with living tissues. He does not construct the machinery with which he deals, and there are many gaps in his knowledge concerning them. Those gaps are bridged by hypotheses which necessarily are abandoned or replaced as knowledge advances.

The living structure with which we deal possesses a property, excitability, which may be defined as the capacity of a living structure to react to environment change. And, having so defined this property, one can next see as its manifestations the response of the whole individual to the sound of a motor horn, the response of a heart to a drug dissolved in the medium which bathes it, and the response of isolated muscle or nerve to the action of an electric current.

The last type of response is the one whereby exact studies of excitability have been made, the ease with which electric currents can be graded both in strength and duration together with the ease of making a muscle-nerve preparation giving a combination seemingly excellently adapted for such exact studies. The lessons thereby learnt from muscle and nerve are then applied to the explanation of such other phenomena as the mode of action of light on the sensory nerve-endings or end-organs of the eye, the application being made in accord with the belief noted above that electric currents excite activity from quiescent muscle and nerve in exactly the same manner as light stimulates retinal end-organs to activity. The science or physiology of retinal stimulation, which has so far developed, unhesitatingly accepts that belief.

If, however, on approaching the subject of retinal stimulation one imagines the possibility that the action of an electric current on isolated muscle or nerve is not necessarily the same as the action of a natural stimulant, then the science which has been developed provides in itself the renitent testimony of the falsity of its primary propositions. For if the proposition be true that the stimulating action of light on a retinal sensory organ is a process akin to that of exciting isolated nerve or muscle to activity by electric currents, then from what we know of the one we ought to able to predict the phenomena of the other. Not only can no such prediction be made but, what is more, for every phenomenon of retinal stimulation actually observed a special hypothesis has to be formulated to explain away the fact that such a phenomenon should not be if retinal stimulation were a process of the type which the primary proposition presume it to be. To pursue such a course may well seem unscientific, but it should be borne in mind that no other course was open so long as men held the beliefs they did. Those beliefs directed the investigator to obtain an explanation of the phenomena of retinal stimulation in terms of what he knew that electric currents did to isolated muscle and nerve. That is to say, he attempted to bring the facts into relation with a firmly held belief that natural stimulation was the same as exciting isolated nerve or muscle with electric currents. The first step to any advance, therefore, if advance were possible, would be to begin to suspect that the action of electric currents on the muscle-nerve preparation did not reproduce natural stimulation. Not the least of the barriers to any such suspicion would be its utter disharmony with all the traditions of the elders.

It should also be noted that, until the advent of the doctrine of Evolution and for some time after, the biological sciences proceeded generally in the style which is still followed by many physiologists. All leading biologists once firmly believed in the literal accuracy of the account of creation which is related in the first chapter of the book of Genesis. This belief constituted their

primary proposition and, so long as they held it, their problem was that of adjusting biological facts to accord with it. The majority of biologists, however, have now abandoned this primary proposition and build their theories from the facts instead. The first step towards being able to do anything like that, however, is a weakening of faith in the primary proposition, and if physiologists generally begin to suspect that the excitation of activity in isolated muscle and nerve by electric currents is not natural stimulation, they would well view matters in a different light.

Attention is therefore next drawn to a gap in the knowledge of physiologists. It was not known and was not even suspected that the proposition of stimulating a rhythmically active organ to greater activity was an essentially different proposition from that of exciting a quiescent tissue to any activity at all. It is the case, however, that by grading the concentration of a stimulating drug or ion in the medium which bathes a heart we can make the same exact study of the stimulation of a rhythmically active tissue to greater activity that one can of excitation by the use of electric currents on isolated muscle and nerve.[1]

When such exact studies were made, they demonstrated that the proposition of stimulating a rhythmically active tissue to greater activity is essentially different from that of exciting a quiescent organ to any activity at all. The two propositions are so different, indeed, that a heart which possesses much of excitability can only with difficulty be stimulated to greater activity.[1]

It has always been imagined, however, that a heart's excitability so determined its capacity to react to drugs that the greater the excitability the more readily did the heart react. But the finding of fact is just the opposite, the greater the excitability, the less readily does it react.

Having thus discovered that the capacity of a beating heart to have its activity modified by environmental change is entirely different from the capacity of a quiescent tissue to be excited to activity by electric currents, we are brought to nomenclature. The latter phenomenon is the one on which all scientific studies of excitability have been made, and if for that reason we call this phenomenon excitability, we obviously require a new name for the other phenomenon. The name which has been suggested for this other is responsiveness, and it may be defined as the capacity of a rhythmically active organ to have its activity modified by environmental change.[1]

The rhythmically active organ also possesses excitability, of course, just as do the members of the muscle-nerve preparation. Excitability, however, determines the capacity to be active at all, and not the capacity to undergo a modification of activity

[1] Burridge—Excitability, A Cardiac Study. Oxf. Med. Pub., 1932.

already present. We have, in fact, the difference between sparking the gases in a motor's cylinders and the acceleration of the whole machine. If we further imagine motor engineers to attempt to explain a motor's acceleration in terms of the laws that govern the sparking of gases in its cylinders, we shall have some idea of the difficulties that have faced physiologists when they have attempted to explain phenomena of responsiveness in terms of excitability. Before deducing, however, anything derogatory to physiologists from what they undoubtedly did in the past, the motorist should try to imagine what he would do in explanation of a motor's acceleration if he knew nothing of the existence of a carburettor, but yet had made a reasonably exhaustive study of the laws of gas-sparking. He could obviously only give an explanation in terms of what he knew, and that would require a lot of hard thinking. If he could advance a seemingly reasonable explanation of acceleration under such conditions, it would be such a great achievement that he might well subsequently be annoyed when somebody else discovered the existence of a carburettor. It is the case at any rate that when the definite evidence of the existence in hearts of a process akin to carburation was first presented, some of those who previously had no conception even of its possible existence were definitely annoyed.

These two distinct properties of living tissues, responsiveness and excitability, are at present confused together throughout the whole body of medicine, one striking example being the clinical condition termed the excitable heart. This condition should undoubtedly be termed the responsive heart, and the difference in the adjective means everything. For if it be a problem of excitability its solution will be found in the laws that govern the excitation of isolated muscle or nerve to action by electric currents, whereas, if it be a problem of responsiveness, we should seek its solution in the entirely different laws that govern a beating heart's capacity to have its activity modified by environmental change.

The suggestion may accordingly be offered to medical teachers to consider matters carefully when they next find themselves prepared to assert that drugs, such as hormones, excite organs to activity, or to make assertions about excitability generally. If it be believed, or there be evidence, that a particular organ would remain inactive until activity was initiated or excited in it by the drug, then its action is probably a problem of excitability. If, on the other hand, there is the evidence, and generally there is, that the drug or other agent modifies, either by augmentation or decrement, activities which have an existence independently of the modifying agent, then there is no doubt that the problem is one of responsiveness. And, if it be a problem of responsiveness, any discussion of it in terms of excitability would require as its fitting accompani-

ment an orchestra playing that well known tune, 'The birds that sing in the Spring'.

Another essential to clarification of ideas where there has been unsuspected confusion is a severe restriction in the use of the terms, excite and stimulate. The former should be closely restricted to the excitation of activity in an organ previously quiescent, as is the case when electric currents excite quiescent muscle or nerve; the latter should be restricted to the augmentation of a pre-existing activity.

Some important implications arise from these results concerning natural stimulation. There can be no doubt of the fact that the stimulation of a beating heart by the hormone, adrenaline, is a natural stimulation. This process we have found to be so entirely different from that of exciting quiescent muscle and nerve with electric currents that the latter teaches us nothing about the former. We also noted above that, unless we make the presumption that an activity of an internal organ is non-existent in the absence of a hormone, then hormones generally may be held to stimulate and not to excite. And if the skeletal muscles of the body are in that constant state of activity called tone, it would appear necessary to put aside everything learnt about excitability when considering their natural stimulation. There is finally the case of the sensory end-organs by which the intact animal reacts to its surrounding. Are they stimulated, or are they excited by environmental change? The inability of faradising electric currents to stimulate their activity is one line of evidence indicating their inherent rhythm; for such currents do not augment the activity of a rhythmical organ, they only derange any activity already present. A second line of evidence is afforded by the fact that the response of an end-organ is graded to the strength of the stimulant, the typical response of a rhythmical structure. The responses and behaviour of retinal sensory end-organs definitely demonstrate, as shown elsewhere, that these have inherent rhythm.[1]

The conclusions reached, therefore, are that natural stimulation is essentially a process of augmenting the activity of some structure which possesses inherent rhythm, and that the actions of electric currents on isolated muscle and nerve throw no light on the nature of this natural process. The presumption made many years ago of the identity of the two processes which are now so demonstrably different was therefore wrong. Physiologists, however, have built on this wrong presumption all their theories and arguments concerning how the organs of the body behave. Every such theory should in consequence now be held to be invalid, and any such argument held to be meaningless.

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[1] BURRIDGE—A New Physiology of Sensation. Oxf. Med. Pub., 1932.

The next gap in physiological knowledge concerns the behaviour of a rhythmically active organ when it is stimulated to greater activity. Here again, for the benefit of those who are not physiologists, we may digress to consider the behaviour of a machine gun and a motor car respectively. The response of the former would be bullet-velocity, and that of the latter its speed.

Since bullet-velocity is independent of the pressure exerted on the trigger, provided the latter is adequate at all, the responses of the machine-gun are 'all or nothing'. In contrast with this, the responses of the motor-car are graded according to the degree of stimulation.

If we consider next their responses to excitation and to stimulation respectively, we note that the machine gun bursts into full activity immediately after it is excited, and reverts to complete quiescence again immediately after excitation ceases, whereas the motor car gradually attains its speed, which is maintained for a short time after the stimulation has ceased, and then the speed gradually returns to what it was before the stimulation was applied. In addition, as is well known, a given amount of speed is more quickly attained by strong stimulation than by weak.

Now there is producible in rhythmically active tissues a specific type of augmentation, the hysteresial augmentation, the main properties of which can be verified by any motorist who cares to study the events which take place when his car is accelerated from 15 to 45 miles per hour, say, and then the speed allowed to drop back to 15 again. Admittedly the proper place for verification of the properties of a rhythmical tissue is a rhythmical tissue itself, but the fact that they can be verified through a motor car or a free-wheeling bicycle throws light on the nature of the augmentation which cannot be immediately supplied by the tissue itself.

In physiological language an acceleration of a motor car from 15 to 45 miles per hour, which was followed by a period of free-wheeling until the speed reverted to 15 again, would be termed a hysteresial augmentation of the activity of the car. Concerning cars we know that a car so stimulated acquires momentum and that after stimulation has ceased this momentum is dissipated by frictional resistance. We can reasonably infer, therefore, from the similarities, that a hysteresial augmentation of the activities of a rhythmical tissue depends on the conferment of momentum on something within it, and that this momentum becomes dissipated through frictional resistance. That further implies that the constituents of the rhythmical tissue which acquire this momentum have surfaces which can meet with frictional resistance from some other medium surrounding or in contact with them. The constituents of living tissues capable of satisfying these conditions are its contained colloids.

The non-physiologist who has read the above may now well wonder why any physiologist should go to the trouble of doing the equivalent of putting down in set terms the behaviour of a motor car when it is accelerated from 15 to 45 miles per hour and then allowed to fall back to 15 again. The answer to this query is supplied by the fact that the rhythmical activity of a living tissue may be in itself as much beyond our immediate perception as are the individual vibrations of a tuning fork. The existence of rhythm under such circumstances can only be inferred from behaviour, but it can be inferred with the same reasonable certainty that one can infer that a tuning fork is vibrating though its behaviour as the provider of a musical note.

The ultimate nature of this living rhythm is unknown. It may be based on regular alterations of physico-chemical-condition, or it may lie in movements of the colloidal particles themselves. The Brownian movements of unorganised non-living colloids for instance may possibly be transformed into motions of regular type in living and organised colloidal systems. There may be indeed the difference between a holiday crowd disporting itself on a parade ground, and a regiment marching past in review order at the same place. We do not yet know, we can only visualise possibilities.

We would next draw some attention to the significance of the facts that the laws which govern the stimulation of rhythmically active structures and their behaviour when stimulated are new discoveries in physiology. It is obviously impossible for anyone to recognise a rhythmical tissue to be what it is from its behaviour when stimulated unless he knows how a stimulated rhythmical tissue behaves. To anyone with these gaps in his knowledge, therefore, an organ or tissue may shout, as it were, the fact of its inherent rhythm, but the shouting will be in a language which the listener simply cannot understand. Matters would be made much worse by the listener or observer presuming that the tissue or organ could not possibly be what it was doing its best to point out that it was. Such has been the past position in much of physiology, for there is now no reasonable doubt that physiologists in the past stimulated structures of inherent rhythm to greater activity in the firm conviction that they were exciting quiescent structures to activity *per se.* As a result they provided themselves with a number of hard puzzles to solve, but the puzzles were those of welding the facts to prior convictions with which they were inconsistent, rather than that of framing theories from the facts themselves. In addition, they could not construct valid theories from the facts because the construction of a valid theory would require a knowledge of rhythmical structures which was not possessed.

A striking example of one of these hard puzzles is provided by the facts that a motor's head-light affects our eyes relatively

little in daylight and much at night. These simple facts, when the problem is presumed to be one of excitability, have provided a puzzle of which there are scores of different and competing solutions contributed by many of the best brains of physiology. From the basis of the inherent rhythmical activity of the sensory end-organs of the retina, however, far from having to put up a theory to explain away the facts, one can predict instead that such facts should be. Alternately, of course, one can appreciate that the facts lead to a theory of the inherent rhythmical activity of the end-organ. But to appreciate where the facts lead one requires the adequate knowledge of rhythmical structures.

It may be judged from this example. that one essential item of equipment for anyone who deals with visual stimulation, whether he be a member of the Vision Committee of the Medical Research Council or one of their research workers, is a knowledge of the properties of rhythmical structures. Without that knowledge, time, and with it public money, may be indefinitely wasted in fitting to a false preconceived notion facts which automatically fit into a different system of philosophy. One might further suggest that a fitting subject for research would be to verify or not by examination whether the behaviour of a stimulated retinal end-organ was similar to that of an isolated muscle or nerve excited by electric currents, or whether it resembled that of a beating heart stimulated to greater activity by a drug.

The physiology of the central nervous system also strikingly exemplifies the barrier to progress which undue attention to the muscle-nerve preparation has provided. When the behaviour of a reflex arc was first tabulated it was appreciated that nothing like it was known as being produced by the action of electric currents on isolated and quiescent muscle and nerve. But to this appreciation was added the presumption that muscular and nervous structres could only behave in the manner in which the quiescent structures of the muscle-nerve preparation behaved when they were excited to action by electric currents. In consequence, a structure, neither muscle nor nerve, was sought in the arc to which its believed peculiar properties could be assigned. The structure selected was the synapse.

What were then unknown were the properties of rhythmical structures. Had they been known the behaviour of the reflex arc would have been recognised to demonstrate within it the presence of a rhythmical structure. And with the examples of the eye and the heart available, the conclusion would have been that either a nervous or a muscular structure could be responsible for the arc's behaviour instead of the conclusion, neither muscle nor nerve. That conclusion, in its turn, would have obviated any reason for assigning the properties to the synapse. The behaviour of the arc would have been realised

instead to demonstrate the inherent rhythmical activity of central neurones.[1]

Now it seems to me unlikely that any man of science would disagree with the proposition that his thinking depends on the activities of the nerve cells in his brain; there is now too much evidence to that effect. It is the concern of physiology to provide a philosophy of the nature of those activities, and the philosophy so far provided considers that those nerve cells sleep until they are awakened by an external agent, the stimulus. It is a philosophy that has prevented physiology from offering any real help either to the alienist or to the psychologist.

One result of this has been the development of such systems of modern psychology as that of Freud which pay no attention to physiology because no attention is possible. They have developed independently of physiology, and make no contact with it. There must therefore be something wrong somewhere. Modern psychology has either gone ahead of physiology or else gone off into the wilderness. The newer knowledge of the properties of rhythmical tissues indicates that modern psychology went chiefly ahead.

Rhythmically active central neurones provide possibilities that simply remain undreamt of so long as one presupposes that they have inherent quiescence and only wake up when they are excited. The activities of rhythmical structure are twofold, they have an activity mediated by rates and an activity mediated by amplitudes. In vision, for example, amplitude furnishes brightness and rate furnishes colour, while in sound amplitude furnishes the degree of loudness and rates furnish the notes. Any idea based on the activities of a system of rhythmical neurones could therefore be expected to furnish us with a concept of loudness or importance based on their amplitudes, and a colour or emotional tone based on their rates, and they do furnish these properties.

Living rhythmical tissues, however, have certain properties which distinguish them from the non-living. They have a normal or neutral rate of beat from which two variations are possible, namely a slowing and a quickening. That indicates the possibility of a primary division of our feeling tones based on quickening and slowing respectively, and a secondary division where we distinguish between neutral and various grades of slowing and quickening. Other possibilities are indicated by the fact that cold produces slowing in a rhythmical tissue whereas heat quickens.

If it next be understood that we do not know what things are, we only know what we believe them to be, and that what we believe them to be is determined for us by the nature of the

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[1] BURRIDGE—A New Physiological Psychology. Arnold. London, 1933.

neural processes taking place in our organs of mind, then it will be appreciated that ideas which are obtained by the activities of living rhythmical systems will be divisible into the three groups of those which more or less warm us, those which we find neutral, and those which more or less chill us.

These divisions are further as inherent to the nature of the processes at work in the brain as is the division of time into successive periods of day and night inherent to the revolutions of the earth in its path round the sun. And just as men before the discovery of the earth's motions had to formulate special theories to explain the regular succession of night and day, so also, until the nature of neural activities was discovered, special theories were required to explain how our ideas should have those divisions which we find to be the inevitable consequences of neural activities being what they are. The moralist makes the subdivision dependent on a conscience, and Freud's *deus ex machina* is the super-ego.

It is no part of our intention, however, to write an essay on the problem of good and evil, we merely wish to give one instance of many which show how the newer knowledge of the nature of neural activities provides automatic explanations of matters about which we can otherwise only speculate without reaching anything in the way of finality. For most if not all of such speculations hitherto made were necessarily based on the material which each individual found in his own organ of mind. Since we are further born to believe in the truth of what our neural activities mediate to us, and also to believe that there is an external reality corresponding to what those activities tell us, the further tendency will be to imagine that a general conclusion has been reached when actually a special case only was considered.

The possibilities provided by rhythmically active neurones will be found examined in more detail elsewhere.[1] Assuming the truth of this doctrine of inherent rhythm, and its truth can only be denied by those whose knowledge of the properties of rhythmical structures is incomplete, it is interesting to note that Freud appears to be the psychologist who attained the deepest insight into the properties of neural processes. At the same time, however, it is to be observed that just as the super-ego dissolves into an automatic consequence of neural processes being what they are, so likewise do such processes as censoring and repressing. But while the newer knowledge of the nature of neural activities leaves little of the Freudian philosophy, it yet shows that he was well ahead of a physiology which imagined that neurones slept until they were awakened

[1] Burridge—A New Physiological Psychology. Arnold. London, 1933.

to activity and then went to sleep again immediately after their awakener had ceased to excite them.

Rhythmical activity, however, had at least to be credited to those parts of the central nervous system which are concerned in respiration. But those who have dealt with the activities of the respiratory centre so far have had inadequate knowledge of the properties of rhythmical structures. They have presumed that carbon dioxide excites the centre to activity just as electric currents excite isolated muscle and nerve. Once that presumption is dropped and attention directed instead to the nature of natural stimulation, mutation rather than slow evolution should be the result here as well as elsewhere.

The last point we have to consider concerns what is commonly known as the internal environment of the body. We are accustomed to speak of the internal and external environments, and are thereby provided with what seems at first sight to be a valuable generalisation. We can thereby class together a change in external environment such as the too near approach of a motor car, and a change in internal environment such as is produced by the imbibition of, say, alcohol, But so long as we so classify the two events, we may blind ourselves to the fact that any alteration in the constitution of the body's fluids constitutes an alteration in the constitution of the dispersing phase of the body's colloids. There is no doubt that this generalisation has generally blinded physiologists and pharmacologists to that fact, because nothing is rarer than any comment on the actions of any drug on colloidal systems. Once, however, the point is grasped that the introduction of any drug into the body produces an alteration in the chemical composition of the dispersing phase of its colloids, both physiologist and pharmacologist can turn to the physical chemist for advice.

Carefully controlled experiments have demonstrated that many agents can exert on living organs two independent actions which possess the characters that are predictable of them if they were effected through colloidal systems.[1] The instances now available are many, and their number is automatically increased as experiments progress. The facts, however, cannot be absorbed into a philosophy whose foundations were laid before anything was known about colloidal systems.

This philosophy presumes that excitability is a primary property of living tissues, whereas we now know that it is derived from the properties of colloidal systems.[1] A further presumption is that excitability is equivalent to the explosiveness of unstable excitable substances, and this in its turn has led to an either-or philosophy, the path thereto being smoothed by the language in which our thoughts have been cloaked. A

[1] BURRIDGE—Excitability, A Cardiac Study. Oxf. Med. Pub., 1932.

quality like explosiveness is obviously only capable of two variations; it may be raised or lowered.

The facts require one to imagine that a single agent can both raise and lower excitability at one and the same time. Attempts to imagine how something can both go up and down at one and the same time appear to have produced nightmares in some instances and bad temper in others. The difficulties here, as with many others of physiology, do not arise from the facts but from the theories to which they are expected to conform.

When the scientist meets new facts inconsistent with his theories, it is popularly believed that he alters his theories to accommodate the new facts. In this case, however, we do not deal with ordinary scientific theory, but with a foundation principle that has been unquestioned for years. All text-books of pharmacology, for example, have been written by authors who have accepted this principle as unquestionably as any medieval author would have presumed that the earth was flat. It must obviously be hard for any man to find in question a statement which he has regularly made for years in full confidence of its truth. Such, however, is the position to be faced, and the older the author, the less capable will he be of assimilating the new facts which contradict what he had taught for years.

Alcohol is the striking example of a drug which, in contradiction to all the traditional theories concerning it, actually exerts two independent and opposite actions at one and the same time.[1] We further select alcohol because it has been the subject of controlled experiments in the laboratory, and uncontrolled experiments by men on themselves. It was the case, however, that the laboratory experiments were over-controlled by presumptions. Before experiments were done, rules were laid down concerning how they ought to be done, and those rules had such a seemingly inherent perfection that they passed unquestioned for years. Yet, as a matter of fact, there is now no doubt that the rules prevented the full observation of what drugs can do as effectively as the requirement that a man carrying a red flag must walk in front of every motor-car would prevent motor-cars from showing their full capabilities.

What may now be called the red-flag controlled experiments indicated that alcohol could only exert one action at any one time. In contrast with this, equally carefully performed experiments, without the red-flag control, demonstrated that it could exercise two opposite and independent actions at one and the same time.

The uncontrolled experiments which men performed on themselves also showed that it could exert two actions at a

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[1] Burridge—Alcohol and Anæsthesia. Williams and Norgate, London, 1934.

time on conduct, and so also two actions on the nerve-cells of the brain. The physiological rule, however, has always been to explain such matters in terms of what is known about muscle, and alcohol provided a divergence of findings between its actions on brain and muscle respectively. The divergence really indicated the necessity for a revision of views concerning muscle physiology, but as the current muscle physiology was believed in with firm faith, the course actually taken was that of adjusting the divergence by special hypothesis relating to the brain. It was suggested that the brain held two anatomically distinct groups of nerve cells so different in their properties that alcohol would depress the members of the one group and stimulate those of the other. These two groups were called higher and lower psychic centres, respectively.

None has yet been able to point out where each of these two groups is, and it is now reasonably certain that none ever will do so because of the advances made in our knowledge of what alcohol does to muscles. Those advances show what alcohol can do to living colloidal systems. It does to them what it does to the non-living; namely, it induces adsorption phenomena and effects changes in the state of colloidal aggregation. In addition, it quickens the rates of living rhythmical structures.

The experiments which men have been performing on themselves with alcohol for centuries can now be used to throw light on the respective parts played by adsorption phenomena and aggregation state in the activities of the nerve cells which mediate our thinking. It also throws light on the significance of the rates of the same changes. Alcohol quickens rates and so has the same action as warmth, an action which according to previous observation would make the world seem rosier.[1]

Apart from these points, however, these experiments which make contact with colloidal systems demonstrate also that the different organs of the body have two sources of potential energy for their activities where previously it had been presupposed that there was only one. The demonstration that there are two sources of energy, it should be noted, is the demonstration of fact; it is inference, however, that they are energies supplied by colloidal systems. But if one does not infer that they are supplied by the colloidal systems present, the number of contradictory hypotheses then required is in itself the testimony that to infer otherwise is wrong. One would first point out, for instance, that although there are two types of reaction similar to those made available by a colloidal system, we are yet going to infer that they are actually made available from

1 **Burridge—Alcohol and Anæsthesia. Williams and Norgate, London, 1934.**

two other sources of whose existence and constitution we have not the foggiest notion. At the other end, while admitting that colloidal systems are present, we should have either to infer that living colloidal systems have no use for adsorption phenomena and aggregation change, or else to infer that, if such phenomena occur, they cannot be manifested in any of the properties presented by the organ. If then we refuse to identify similars with similars; the refusal makes necessary such a number of hypotheses having no basis of fact at all that one can only deem the refusal to be wrong.

The existence of two sources of energy, where previously only one was believed to be, makes as much difference to our philosophy as the discovery that the action of electric currents on isolated muscle and nerve is not the same as natural stimulation. It is necessary to give up the idea that the machinery of the body derives its energy from the explosion of a sort of definitely composed somatic or neural dynamite, and replace it by something for which the carburettor of the motor car is the better analogy. The organs of the body work on a mixture of two sources of energy and the mixture is infinitely variable in its composition.

Some idea of the possibilities opened up may be obtained by considering the simple indeterminate equation, $H+L=T$. It is one which covers many activities of our organs of mind. The equation indicates that two sources of energy, H and L, co-operate together to produce a result, T. These two sources of energy are provided by colloidal systems, and they have been called the kinesiphores, because on them all bodily movements are borne.

The equation puts the activities of the organ of mind on an energy basis. Having done that, it is certain that there is a limit to the capacity of the brain to generate energy. This limit is indicated by T, and the existence of this limit further sets up a relationship between H and L. The more there is of H, the less can there be of L, and vice versa. This relationship in turn holds good of two antagonists fighting each other to obtain as much as each can of a limited stock of something, as well as of two co-operators working to a common end. It is easy to find psychic phenomena with this relationship.[1]

The source of energy, H, gives us judging capacity, whereas L provides the data which we judge. Hence, when the data are sufficiently large, we lose the capacity to judge them well. Music from the too-loud-speaker is an interesting example of data being so large that we cannot apply to them enough of a different type of energy to judge them well. The reader or

1 BURRIDGE—A New Physiological Psychology. Arnold. London, 1933.

listener is next invited to consider the possibilities arising from the same strengths of data being delivered to minds of different capacity in T. Who would complain about the loud speaker first, the possessor of the large or the possessor of the small powered mind ? On the other hand, since equal strengths of external stimulation can generate different amounts of L in different individuals, quite another group of complaints is thereby made possible.

We can do no more than indicate, however, some of the possibilities that arise from the donation to nerve cells by the colloidal systems constituting them of two sources of energy. Those who wish to pursue these matters further can do so through the material presented elsewhere. Here, we just hover on the borders of a new land ready for detailed survey.

It is very easy to perform the experiments which demonstrate the existence of two sources of energy in living tissues, and also to perform those which reveal the properties of rhythmical structures. The simplicity of the apparatus required may indeed be its chief defect. For so long as scientists are human, they must probably automatically imagine that some new and wonderful machine constructed to give electric shocks to an excised nerve in a manner never previously known must give results of a value commensurate with the machine's cost and complexity. By the side of such a machine a bent pin tied to cotton together with a piece of glass pipe and some rubber tubing may well on first impressions seem incapable of giving results of any value at all. The ultimate test, however, must be the usefulness of the results which each machine affords. The bent pin and cotton revealed the properties of rhythmical structures, and so produced the evidence of the inherent rhythm of living structures, as well as the fact that they had two sources on energy for their activities instead of the one previously believed in. They thereby produced the evidence that the science of Physiology had been built on wrong foundations. Physiology, however, is also a foundation science for Medicine, and so whatever was faulty in Physiology provides still greater fault for Medicine in general.

The position in the past has been that physiologists as a class have handed over to the medical profession the wrong measures for weighing the facts of clinical experience. Every phenomenon should therefore be re-measured. It may, however, be held as fortunate that while few medical men are machine-gun specialists, there are also very few who are not acquainted with the mechanism of motor-cars. Hence we can finally point out that living organs are as motors born ticking-over with abundant supplies of fuel and lubricant generally available. All stimulations are augmentations of a pre-existing activity and not the initiation of activity in structures ordinarily at rest. As regards the nervous system and its relays, the new conception

of rhythmically active or vibrating neurones enables anyone, when using his wireless set, to learn more about the mechanism of incoordination in fever and drunkenness than ever he had learnt before.

Section of Physiology.

Abstracts.

1. The nutritive value of *Cicer arientinum* (Gram).

D. D. CHATTERJEE, Agra.

Gram in sprouting form is more nutritive than in any other form, except when mixed with wheat. Wheat is more biologically nutritive than gram. Rice and urid (*Phaseolus radiatus*) are of less biological value than gram.

Rats on sprouting gram and milk gave the maximum number of young per litter, those fed on gram gave the least. The addition of milk to cereals promotes growth.

2. The biological oxidation of inositol.

N. DAS *and* B. C. GUHA, Calcutta.

The presence of an inositol-oxidizing system in the brain, kidney, and heart muscle tissue of the rat has been reported before. In this paper the action of certain activators and inhibitors on this dehydrogenase system has been investigated.

3. Experiments with insulin.

SRI KRISHNA, Lucknow.

Insulin, Lilly brand, is active in doses so small as one-millionth of a unit. Such small doses stimulate the heart. Large doses depress and, in addition, depress more than they stimulate. Assuming, however, that an injection of insulin is spread over about 5,000 c.c. of fluid, it would appear that the doses clinically employed stimulate.

The effects of adrenaline last much longer when insulin is present. The maximum effect of the adrenaline, however, takes slightly longer to develop. If the latter be taken as evidence that insulin antagonizes the action of adrenaline, the former is evidence to the contrary.

4. Time of appearance of diastatic activity in human saliva.

S. N. MATHUR, Lucknow.

From the study of the diastatic activity of saliva of a number of small infants, the author has found that the belief that an infant, before the age of 6 months is unable to digest starchy foods because of the lack of any diastatic enzyme in its saliva is not true. A diastatic enzyme has been found in infant's saliva on the very first day of its birth.

5. Enzyme dextrinase.

S. N. MATHUR, Lucknow.

The present author finds that 'Ptyalin' is a mixture of more than one diastatic enzyme, and that the enzyme dextrinase may be one of them. This enzyme is present at birth and before the enzyme amylase makes its appearance, the latter may not be present for the first few days after birth.

6. The percentage of hæmoglobin in 'healthy' Indians.

S. N. Mathur, Lucknow.

If a medical student be taken as a specimen of a 'Healthy' Indian, then the percentage of Hæmoglobin as compared to the book standards is only, on the average, between 75 and 80% of the normal.

7. Seasonal variations in the hæmoglobin in Indians.

S. N. Mathur, Lucknow.

There is a regular rise and fall in the percentage of Hæmoglobin in Indians, and the curve runs parallel with the curve of the outside temperature.

8. Diastatic enzymes in fæces of horse, cattle, goat, sheep, and ass.

S. N. Mathur, Lucknow.

Diastatic enzyme was present in the fæces of all these animals, but is most abundant in that of the horse.

9. Changes in H-ion concentration of urine with the meals.

S. N. Mathur, Lucknow.

The regular changes in H-ion concentration of saliva with meals, recorded by the author elsewhere (*Indian Medical Gazette*, July 1930), are reflected in the urine.

10. Changes in H-ion concentration of saliva and variations in CO_2 tension in the lungs with meals.

S. N. Mathur, Lucknow.

Changes in H-ion concentration of saliva occurring with meals, as shown elsewhere, are reflected in the CO_2 tension of the lungs.

11. H-ion concentration of saliva and its relation with the H-ion concentration of the gastric juice.

S. N. Mathur, Lucknow.

Changes in the H-ion concentration of saliva run parallel with the changes in H-ion concentration of the gastric juice. The latter can thus be indirectly studied through changes in the pH of saliva.

12. Cardiac slowing during asphyxia and administration of carbon-dioxide, and its effect on minute volume.

S. N. Mathur, Lucknow.

It has been shown that during the later stages of asphyxia and administration of carbon-dioxide there is a slowing of the heart, which is associated with an increase in minute-volume. This is suggested to be a protective mechanism of the heart in times of stress.

13. Effects of carbon-dioxide and asphyxia on venous pressure.

S. N. Mathur, Lucknow.

It is shown that the improvement noted in the output of the heart after administration of carbon-dioxide is independent of the venous pressure.

14. Carbon-dioxide and oxygen saturation of blood.

S. N. Mathur, Lucknow.

After administration of carbon-dioxide the arterial blood is found to be much better oxygenated. Carbon-dioxide thus benefits both respiration and circulation.

15. Sequence of events in the failure of vital centres in medulla.

S. N. Mathur, Lucknow.

These centros fail in this order, respiratory, cardiac, and vasomotor. The latter centre remains active long after the heart has stopped.

16. Blood pressure and over-ventilation.

S. N. Mathur, Lucknow.

The well-known fall of blood pressure in over-ventilation is not only due to failure of the vasomotor centre but to a much larger extent to failure of the heart, the beats of which decrease in amplitude due to incomplete relaxation.

17. Carbon-dioxide and sunstroke.

S. N. Mathur, Lucknow.

With a rise in temperature respirations increase in rate and decrease in depth. The latter factor tends to counterbalance the former in maintaining the normal CO_2 tension in the body fluids. With prolonged exposures, however, the latter factor fails and the CO_2 is washed out. The skin capillaries then constrict, and accordingly the heat loss by sweating and other physical means is sufficiently diminished. In consequence the body temperature suddenly rises. This rise of temperature aggravated by loss of CO_2 is responsible for the sudden failure of the cardiac and respiratory centres.

18. Sprouted gram.

S. N. Mathur, Lucknow.

Besides the increased content of certain vitamins, sprouted gram is also more easily digestible than the non-sprouted because of the diastase that it produces. On the other hand its digestibility with saliva does not increase to any appreciable extent. Taking all things into consideration, it is suggested that tomatoes, which are as cheap or even cheaper in certain seasons, and similar other fruits which contain a far greater amount of vitamins, be substituted for the sprouted gram with which school children are now being treated in many schools

19. Coagulation time of vulture's blood.

S. N. Mathur, Lucknow.

If precautions are taken to preserve its 'plasma-protein-complex' by avoiding contact with tissue fluids, the coagulation time is indefinite. The coagulation time, however, decreases rapidly if the blood be agitated

with a water-wetable substance or brought in contact with tissue fluids, particularly the extracts of glandular tissues, i.e. agents reputed to disturb the plasma-protein-complex. In this respect the vulture, a pure meat eater, resembles the domestic fowl, a vegetable feeder, on which most of the experiments done with bird's blood have been performed. The peculiar tendency of delayed coagulation in birds, thus, does not depend on diet, but on some other factor.

20. Some differences in the responses of English and Indian cats.

S. N. Mathur, Lucknow.

Indian cats are more resistant to the influence of anæsthetics, e.g. in ether anæsthesia they show very little salivation, show a more uniform blood pressure, and a steadier heart and respiration rate during operative and experimental manipulations; they are on the whole better experimental animals than English cats.

21. A method of staining neurofibrils.

B. B. Sarkar, Calcutta.

Pieces of nervous tissues are fixed in 10% formol. [A tissue which has been kept in formol for years e.g. human brain preserved in formol also gives very good results.] The tissues are then treated with a solution containing—

Tannin ..	..	5 grms.
Distilled water	..	90 c.c.
Ammonia (Conc.)	..	10 c.c.

for several days at laboratory temperature or for 2 to 4 hours at 36°C. After removing the tissues from the solution they are rapidly rinsed in distilled water and transferred to a large volume of 1% solution of silver nitrate and kept in a hot chamber at 40°C. for about 4 hours. Sections are cut by embedding the tissues in paraffin in the usual way.

By this method the nerve fibrils are stained an intense black, the nuclei of cells deep brown, and other parts of the section light brown to yellow. As serial sections can be cut and carefully mounted, it is possible to follow the course of the finest fibrils. The stain is very permanent.

22. The basal metabolism of young men at Hyderabad, Deccan.

S. A. Rahman, Hyderabad (Deccan).

Basal metabolism tests and physical character studies were made on 32 young men at Hyderabad, Deccan. Most of the subjects were medical students. The nutritional state of the subjects was investigated according to the Pirquet's system. The average pelidisi for 30 out of the 32 subjects was found to be 92 ± 4. The blood pressure was found to be considerably lower compared to the western standards. The average systolic blood pressure in 30 out of the 32 subjects was $100{\cdot}4 \pm 11$ mm., the average diastolic pressure $71{\cdot}8 \pm 5$ mm., and the average pulse pressure $28{\cdot}6 \pm 7{\cdot}2$. The basal metabolism was found to be 6·8 per cent. below the Harris-Benedict and 8·7 per cent. below the Aub-Dubois standards. The factors which may tend to bring about this low level of metabolism are discussed. The possibility of the humid climate being a factor in lowering metabolism is suggested.

Eight of the subjects who were vegetarians showed the basal metabolism on an average about two per cent. lower than that obtained for the whole mixed group. For height and age the weight in this group of subjects was less than the American standards.

23. Some observations on the Crenation of Red Blood Corpuscles.

N. M. BASU, R. GHOSH, *and* B. K. GHOSH, Calcutta.

Equal volumes of blood and 0·4% Pot. oxalate solution were mixed in a tube, 5 c.c. each of normal (isotonic) saline, twice normal (2N), 4N, 8N, 16N, and 32N were taken in test-tubes and to each of these 1 drop of the diluted blood was added and mixed by rotation. Each of these samples of blood was then placed on slides and covered with vaseline at the edge so as to prevent evaporation. These were then examined immediately and after 45 min. to one hour. Micro-photographs were also taken. They reveal a very curious phenomenon. Crenated corpuscles were most numerous in isotonic saline and their number dwindle as the strength of saline increases. Hæmocytometer count shows that the percentage of R.B.C. diminishes with increase in strength of saline and some of the cells are found to increase in size in concentrated saline. Discussion of these results is given.

24. Observations on the relation of blood pressure to age, height, pulse, and weight of some Bengalee Hindu gentlemen.

N. M. BASU, Calcutta.

The blood pressure (both systolic and diastolic), pulse, age, height, and weight of 75 Bengalee Hindu gentlemen of moderately good health were taken. The blood pressure was recorded with a new form of sphygmo-oscillometer in which the diastolic pressure is obtained by noting the maximum oscillation of the needle. The relations between blood-pressure (both systolic and diastolic) and height, weight, age, and pulse were plotted out as curves, the abscissa denoting height, weight, age, and pulse respectively, and ordinates representing systolic and diastolic pressures. These curves were compared with similar curves obtained in other countries. The variations are noted and the results are discussed.

Section of Psychology.

President :—J. M. SEN, ESQ., M.Ed., B.Sc., F.R.G.S., F.N.I.

Presidential Address.

MEASUREMENT IN EDUCATION.

LADIES AND GENTLEMEN,

I feel myself highly honoured by being called upon to preside over the deliberations of the Psychological Section of the Indian Science Congress. At the twelfth session of the Congress held at Benares in 1925 the Psychological Section had its first sitting and since then eminent psychologists like Dr. N. N. Sen Gupta, Lt.-Col. Owen Berkeley Hill, Mr. Haridas Bhattacharya, Dr. Michael P. West, Dr. M. V. Gopalaswami, Rev. A. S. Woodburne, Mr. M. N. Banerji, Dr. Girindra Sekhar Bose, Mr. N. S. N. Shastry, Dr. S. C. Mitra and others have presided over its deliberations. In the past I attended this Congress rather as an educationalist—a school-master—than as a psychologist; and I have come to you this year also in the same capacity. I have thought this, therefore, a fitting occasion on which to discuss with you the relation of psychology and education. I shall not however discuss all aspects of the relationship that exists between psychology and education. Dr. Michael West discussed some of the aspects in his presidential address of this Section of the Congress in 1928. I want to discuss with you only that aspect of the relationship which is commonly known as the Measurement in Education with its logical question—Is measurement in education accurate ?

In all problems of education two things are of fundamental importance ; one is *the child* who is to be educated and the other *the environment* in which he grows up. But both are variables ; no one can fully predict what a child is going to be, nor is it impossible to change the environment to a certain extent. Education is therefore *a function of two real variables.* No mathematician can however lay down any precise formula governing the relationship of these two variables.

Common sense says that all human beings are capable of education. History of man from the earliest stage goes to strengthen this belief. There is however great difference of opinion regarding the nature of the child as raw material on which the educator may work. Some persons consider the child as a little angel who comes to this world from heaven which is his home ; while others regard him as full of original sin. Practical knowledge about children does not fully

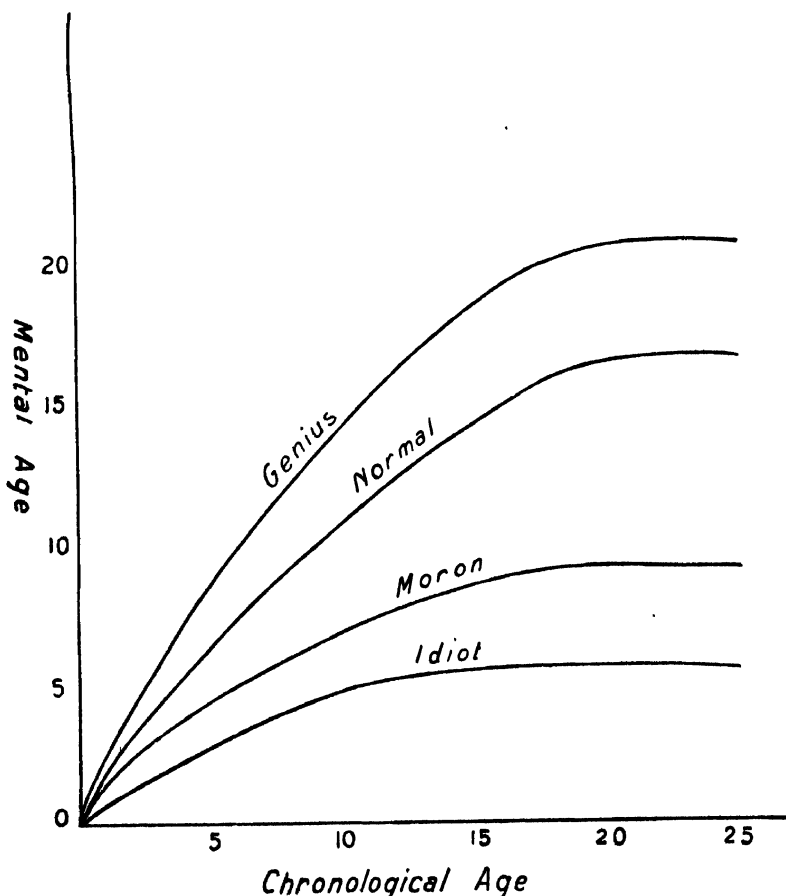
substantiate the views of any of the theorists. The child is neither angel nor devil; nor is he merely a lump of clay to be moulded by the teacher into any pattern he likes.

Every human being comes into this world with certain possibilities and limitations. These must be regarded as things given to the child. The child begins life as a sort of field of operations for two forces that sometimes work in harmony, but frequently oppose each other; these forces are known as heredity and environment. Heredity is generally accepted as an ordinary principle of life. 'Certain more or less doubtful laws of heredity are enunciated, are generally accepted, and are acted upon in practical life in connection with medicine and insurance in the case of human beings, and in connection with breeding and grafting in the case of animals and plants.' For the teacher the problem of heredity is an enquiry into the question of the inheritance of acquired characteristics, viz.: Does the child inherit from his parents qualities that they have acquired for themselves during their life time? In education the teachers are liable to the fallacy of apparent transmission. Characteristics acquired by the fathers may appear among the children not because they are transmitted but because they are again acquired by the children. Mr. Bernard Shaw, who does not believe in the hereditary transmission of characteristics, writes in *Man and Superman*—'The bubble of heredity has been pricked. The certainty that acquirements are negligible as elements in practical heredity has demolished the hopes of educationists as well as the terrors of the degeneracy mongers; and we now know that there is no hereditary governing class any more than a hereditary hooliganism'. The demonstration of the fallacy of the doctrine of the transmission of acquired characteristics cannot be regarded as a calamity for education. No doubt it shatters the hope that the teacher may produce an ever improving set of human beings by accumulated improvements in succeeding generations. But it also brings the joy of knowing that from however bad a home a child comes —if only he comes early enough—he brings with him no handicap from his parents' acquired traits. This is well illustrated in the evidences of the authorities of the Bernado Homes, the Salvation Army, and in the records of the municipal and other authorities in western countries who have taken means of reclaiming the children of depraved and criminal parents. Confirmation is to be found in the careful records which the Glasgow municipal authorities have kept of some 630 cases of children removed from evil environment when still very young, and sent to the country to be brought up in ordinary families at the expense of the municipality. Of the six hundred and thirty children whose career has been kept under close observation for years, only twenty-three have gone wrong. Yet these children came from the worst possible stock. At the

Psychological Section of the Indian Science Congress held in Bombay in January, 1926, I also gave instances of five slum boys between the ages of eight and ten who when removed to a better environment and given some schooling in the new environment in Calcutta, showed a remarkable increase in their I.Q.'s (intelligence quotients) within a comparatively short period. It is perfectly true that the children of parents who had received some education themselves can be taught more easily than the children of those who had not the opportunity of receiving any education. But all the same the former group will have to be educated in almost the same way as the latter group. Hence it can be asserted that *educability can be transmitted but the results of education cannot be transmitted.* From the point of view of practical teacher the influence of the environment is the most important factor. The pupil's qualities must be taken as they are given. But in the matter of environment the teacher can certainly manipulate it in such a way as to produce a definite effect upon the pupil.

Many educational psychologists attempted to define the meaning of the word 'intelligence'. There were almost as many definitions as writers and of these definitions no two fully conveyed the same meaning. The reason for this is that no one knows precisely what intelligence is. No one even knows the exact nature of any one of its separate faculties or functions. Apart from the formal definitions expounded in recent years, it has been described as 'understanding' or 'the capacity to understand', 'intellect', 'mental acuteness', and so on. Ebbinghaus had called it 'intellectual ability' and has said that it consists in the 'elaboration of a whole into its worth and meaning by means of many-sided combination, correlation and completion of numerous kindred associations'. Spearman looked upon intelligence as a general function, the outward manifestation of a high correlation between each of the separate functions, while Thorndike has held that it is a multitude of functions. But perhaps it would be best to give the term 'intelligence' a comprehensive meaning by saying that it is the general capacity which consciously adjusts the individual's thinking to new requirements—general mental adaptability to new problems and new conditions of life. If this view be accepted it will be realized that when it is stated that intelligence of an individual increases (though differently in different individuals) from birth to sixteen or eighteen years of age and thereafter remains constant, the statement assumes a prominent position in regard to his education. For most part of this period he is at school and the teacher can help him in increasing not merely the pupil's knowledge but his native intelligence as well. It is therefore of utmost importance that the conditions of the school atmosphere should be such that it can help in increasing the Intelligence Quotient of each and every individual. Those

who are found to be mentally retarded should be sent to special schools for mentally defectives where a special atmosphere for their education will have to be created. The classification of pupils according to mental age therefore becomes a condition precedent to good teaching in class rooms. The curve given below gives the growth of intelligence of pupils of various types.



The above curve also illustrates why money is wasted in secondary schools for the education of children who are not fit to proceed to High Schools ; some of the children are uneducable in ordinary schools. With the growth of education in India this problem is assuming a position of great importance in the administration of education by governments and local bodies.

The science of measurement in education is in its infancy and the art of measurement is younger still. Yet both have developed in western countries at such a phenomenal rate during the last twenty-five years as to make this movement the most

dramatic tendency in modern education. The American educationist William McCall states that 'the art of measurement is younger than the science of measurement because the abler workers have, of necessity, devoted their energies almost exclusively to the origination of fundamental technique. But the whole movement was so promising in the way of concrete assistance in meeting educational problems that practical educators have irresistibly demanded that the science of measurement be turned into the art of measurement almost overnight. Hence the last few years have witnessed a feverish effort to meet these demands. The result has been numerous mistakes and remarkable successes'.

When mental testing was first introduced in France and in the U.S.A., the need for Group Tests was hardly felt. The children in these countries were tested individually by the Binet-Simon Scale and the Stanford Revision of it. The children were given individually a few psychological tests ranging from simple sensory and motor tests of voluntary attention. Then calculations were made to find out to what extent the results agreed with the teachers' empirical estimate of the general intelligence of these children. The higher the correlation between the results obtained by mental testing and the teachers' empirical estimate the more satisfactory was the set of tests regarded as an index of intelligence. Several tests were devised by the psychologists in England, France, and the U.S.A. to test the general intelligence of children by measuring the power of thinking and the power to understand and to reason. Oral and individual testing is no doubt considered more searching than written and collective testing. But by the former method it takes a long time to test a few hundred children. Hence the need for Group Tests was keenly felt; and the stern necessity of the Great War (1914–18) gave birth to it in America. The psychologists were asked by the Army Authorities to declare quickly who, out of a large number of recruits, could be taken in the Army as privates and commissioned and non-commissioned officers, and who should be altogether rejected on the ground of incompetency due to the insufficient general intelligence. So successful and so impressive were the results of the Group testing in the Army that after the War such tests were introduced into many colleges and schools in the U.S.A. and England. In India up to the year 1921 only a few isolated experiments with intelligence tests had been conducted by missionaries engaged in educational work, amongst whom may be mentioned the Rev. E. L. King of Narsinghpur and the Rev. D. S. Herrick of Bangalore. After 1921 the Bureau of Education of the Government of India devised a series of tests based on the Stanford Revision of the Binet-Simon Tests suitable for children attending Indian schools. Experiments with these tests were carried on by Miss Gordon of Saidapet, Dr. Michael West of

Dacca, Mr. Spence of Jubbulpore, and Mr. Wyatt of Lahore. A Hindustani Binet Scale was also devised by Dr. C. Herbert Rice of the Forman Christian College, Lahore, in 1925. During the years 1924 and 1925, Group Tests based on the Otis Intelligence Scale were first devised in India by myself working in collaboration with Professor G. Dasgupta of the David Hare Training College; and papers on the subject were read and discussed at the Indian Science Congress held in 1925 and 1926. Subsequently Professor P. C. Mahalanobis of the Presidency College devised certain tests and the results obtained by him and his collaborators were published in the *Sankhyā* (The Indian Journal of Statistics). During the last ten years several other workers have also been working on the same lines in different parts of India.

Some of the tests are used to test (i) the ability to carry out commands, (ii) the ability to work out reasoning problems in arithmetic, (iii) the ability to select the best reason for a statement, (iv) the ability to detect likeness or differences, (v) the ability to reorganize disarranged sentences and to indicate whether a sentence is true or false, (vi) the ability to complete series of numbers, (vii) the ability to select by analogy, and (viii) the range of general information. There are also tests covering the following subjects: (*a*) information, (*b*) similarities, (*c*) memory, (*d*) absurdities, (*e*) comparisons, (*f*) relationships, (*g*) symmetries, (*h*) designs, (*i*) counting, and (*j*) directions. Some tests like the Sen and Dasgupta Tests (based on the Otis Intelligence Scale) are designed to measure (1) ability to follow directions, (2) ability to copy designs, (3) ability to compare pictures as to likeness or differences, (4) ability to complete pictures, (5) ability to accompany symbols with certain digits, and (6) ability to compare words as to sameness or oppositeness in meaning.

With the introduction of compulsory elementary education in the different provinces of India the problem of classification of scholars fit to proceed for secondary education is assuming a gigantic proportion on account of millions of children coming within the scope of educational laws. A quick process of classification is possible by application of educational tests. The purpose of the testing programme is fourfold, viz. (*a*) to determine as nearly as possible the native capacity for learning possessed by each pupil, (*b*) to determine each pupil's present educational achievement or attainment, (*c*) to effect better grade placement for those pupils not properly graded, (*d*) to report the test results in such a way that the teacher would be able to make the greatest possible use of them. The tests which ought to be devised for the purpose may vary in different provinces to suit local conditions but certain non-language tests can also be prepared which can be applied generally in any part of India. In the preparation of the tests the following criteria must be borne in mind: (i) Are the tests the best

ones to yield the desired measure? (ii) Do the tests yield highly reliable and valid results? (iii) Are the tests scorable by untrained persons under supervision? (iv) Are satisfactory norms or standards available? (v) Are the tests scientifically standardized in all respect? The task is gigantic and is not an easy one. Help of the Government of India, of the Provincial Governments and of the Indian States which want to introduce compulsory education is absolutely necessary to make the scheme a success. It may however be stated that if the tests can be applied at different stages in the career of each pupil then waste in many directions can be prevented.

So far as college education is concerned it is necessary to devise some accomplishment or achievement tests. Any adequate evaluation of the effectiveness of instruction in a particular college course or department requires the use of methods of measuring the results of instruction which give valid evidence of the degree to which students are reaching each of the important objectives of the course or of the department. Usually college instructors base their estimates of success upon subjective judgments of the students' abilities as demonstrated in term papers and in traditional examinations. But in developing a method for measuring the students' attainments in each of the important objectives of college work it is essential that all important objectives should be included. Those objectives which are accepted by a given college must be considered in any adequate programme of measurement of the effectiveness of the institution. These are :—

Type A :

Acquisition of information—which includes recalling specific facts, terminology, and statements of general principles.

Type B :

Reasoning or utilizing scientific method—which includes induction, testing hypotheses, and deduction.

Type C :

Locating relevant data—which includes a knowledge of sources of usable data and skill in getting information from appropriate sources.

Type D :

Skill characteristic of a particular subject—which includes laboratory skill in the sciences, mathematical skill, and the like.

Type E :

Applying standards to technical performance—which includes the knowledge of appropriate standards, ability to

evaluate the relative importance of several standards which apply, and skill in applying these standards.

Type F :

Making reports—which includes the necessary skill in reporting projects in engineering, or reporting experiments in science, and the like.

Type G :

Consistency in applying a point of view—which is deemed important in courses in philosophy.

Type H :

Interest in important social problems—which includes interest in reading about and in investigating problems.

Type I :

Enjoyment in wholesome recreational activities—which includes enjoyment of literature, music, and art.

Type J :

Character—which is inclusive and may well involve many specific factors.

While science as the pursuit of power is becoming increasingly triumphant, science as the pursuit of truth is being killed by a scepticism which the skill of the man of science has generated. As long as science was a search for truth—a truth independent of human interest or purpose—the scientist might ignore the human factor. But, if science is the pursuit of power, it must be power to some end. This end must always be determined by reference to human well-being. Educational research which builds, on the assumptions, the laws, and the techniques of the physical sciences, should sense in this interpretation a challenge to a critical consideration of its own values and practices. For a challenge exists, and reconstruction in the philosophy and programme of research is sadly needed. What are the implications of this reconstruction in science ? The careful selection of problems in terms of their significance for human well-being and happiness is of basic importance in research. In the main, the research worker in education has been without a vision—a slave of conventional education. He has improved and polished its practices, but he has not challenged its fundamental assumptions. Reading as reading is taught better ; abstract numbers are mastered more rapidly and permanently ; examinations are more detailed and reliable but still factual. In many respects he is like a piece-worker in a big factory, doing his bit in the service of some larger plan that he does not question or evaluate. If he would meet the challenge, he must become a philosopher and choose which

values he will serve. He must also give up his sense of finality and authority. The educational scientist is sometimes found to be conceited and arrogant; he lacks the intellectual humility of the true scientist. But the foundation of his conceit has been destroyed by the research of the physicist; the laws of science are conventional and convenient arrangements, never more than approximation; they are generalizations, invaluable as guides to thinking. Through adherence to the old interpretation, science, which has been the major instrument for liberating the intelligence of the race, became the agency in the hands of scientists in education for making the exercise of intelligence by lesser individuals unnecessary. It is a false conception of the function of science to determine, for instance, the most common interests of children in nature or in reading, and then to prescribe a curriculum for all children, which means ten thousand unique individuals, upon that basis. Such data are invaluable tools for the teacher, but as patterns they are abortive. The research worker in the field of education must select his problems by their human significance. He must have a standard of values. From modern philosophy and science come these suggestions. Educational research should be engaged primarily with problems that concern the realization of a more dynamic organism, a democratic way of life, and a liberated but disciplined intelligence. Suppose we examine the conventional school in whose service the educational psychologist has willingly and industriously enlisted. What does it seek as its goal? Is it organized to instil interests and drives? Does it increase dynamic? Is it organized to make thinkers? Does it foster the inquiring mind? Does it practise its pupils in the methods of child research? The answer is an almost universal negative.

I have already mentioned that a change in environmental conditions can accelerate the growth of intelligence of a pupil prior to his attaining the age of sixteen. The secret of evolution lies, in short, with the environment. In the environment, in that in which things live and move and have their being, is found the secret of their being, and especially of their becoming. And what is that in which things live and move and have their being? It is Nature, the World, the Cosmos—and something more, some one more, an Infinite Intelligence. Everything that lives, lives in virtue of its correspondences with this environment. ***Evolution is not to unfold from within; it is to infold from without.*** Growth is no mere extension from a root but a taking possession of, or a being possessed by, an ever-widening environment, a continuous process of assimilation of the seen or unseen, a ceaseless redistribution of energies flowing into the evolving organism from the Universe around it. The supreme factor in all development is environment. If a tree is to be judged in terms of the immediate environment of its roots, it is a clay tree; but if it is to be judged by stem, leaves, and

fruit, it is not a clay tree. If the moral or the social organism is to be judged in terms of the higher influences which enter into the making of its stem, leaves, and fruit, it is not a material organism. Everything that lives, and every part of everything that lives, enters into relation with different parts of the environment and with different things in the environment. A child does not grow by spontaneous unfoldings. The process is fed from without. The body assimilates food, the mind assimilates books, the moral nature draws upon affections; the religious tendencies nourish the higher being with ideals. Time brings not only more things, but new things. It is therefore clear that the main function of the teacher is to create an atmosphere in which the mind of the child can grow unimpeded in various directions, and in which the general intelligence (or the central intellective factor 'G', as it is called by Professor Spearman) can grow freely and thereby help in producing a better type of man.

In the early days of intelligence testing eminent psychologists committed themselves to extravagant programmes. One of these was the notion of 'homogeneous grouping'. How a psychologist, of all people, and an educational psychologist at that, could use such a phrase must remain a mystery. Like the 'purple cow' of the nonsense rhyme, I have never seen a homogeneous group; I never hope to see one. However you group children, scientifically or unscientifically, by guess or by test, by intuition or by rule, the one sure thing is that the pupils will remain individually unique and different. Lately the much sounder expression, 'ability grouping', has gained acceptance. But ability has been again too narrowly conceived in terms of intelligence as measured by tests or of 'school achievement', or of some combination of these two. Now it is hardly to be questioned that ability as thus defined is a primary factor in a child's adjustment to the schools, not only of to-day but as they will be when progressive educators shall have remodelled them. In practice, however, grave administrative difficulties will have to be encountered. Trait differences, that is the difference from ability to ability within the single individual, have proved almost as great and far more troublesome than the differences between individuals. In despair, many educators have concluded that by having groups of one pupil each can we really adjust to abilities. There is no need here to speak of either the administrative or the pedagogical objections to such a completely individualized programme. It is clearly the counsel of despair and so far as I am aware no one has actually proposed it for our schools. Certainly no school practises it. Practical teachers and educationists reached the conclusion that the individual must become the real unit of teaching, though for economic reasons, the class could not be comfortably abolished. At the present moment we all believe in ability grouping but we

do nothing about it—or at least too little. We continue to group children according to the most mechanical and arbitrary of all possible bases, that of age from birth. That for many children, perhaps, for most, this works well enough is, of course, the answer of sloth. We dare not be satisfied till we have secured for every child that combination of associations with his fellows which is most fruitful for him in the light of all his abilities, all his attitudes, all his traits of personality. This is not easy. It requires detailed knowledge of not only the child to be grouped, but the other children with whom he is to be associated. Equally clearly, it calls for a flexibility of administrative arrangements and a flexibility and imagination of teaching which is literally nowhere yet attained. Until we have more clearly seen and more honestly striven for these ends, the term ability grouping may serve with others to remind us of our supreme duty to the individual child.

I have already discussed the problems concerning general intelligence tests, memory tests, reasoning tests, ability tests, vocational tests (i.e. tests for determining skill for a particular vocation in life) in schools and colleges. But these do not cover all types of pupils. There are patient plodders in all walks of life and it is worth while finding them out while they are in educational institutions. By means of a series of tests, Dr. E. Webb has determined that there is a second central factor in life known as 'the persistence of motives' (denoted by '*W*'). Even this cannot explain all cases. Mr. Maxwell Garnett has brought to light a third independent factor, viz. 'originality' or 'cleverness' (denoted by '*C*'). High values of 'C' characterize men of genius and first rate artists, poets, and scientists. My own teacher, Sir T. Percy Nunn of the University of London, regards 'that the general nature of a person's endowment may be registered by a single point in a tri-dimensional record or graph, the co-ordinates of the point being the values of the three independent factors "G", "W", and "C" described by Spearman, Webb, and Maxwell Garnett'. These fascinating researches enable us to determine 'the promise and potency of the individual so far as these depend on his endowment'. These however prove that there cannot be any clash of interests of individual pupils in class room and outside. All three factors 'G', 'W', and 'C' cannot be identical even in two cases, not to speak of three or more cases. Hence it is necessary to develop the potentialities of a pupil during his school age by creating for him an atmosphere of study and character congenial to all and not inimical to the best interests of the society as a whole. This is the task which the teachers of our country will have to face under the stress and strain of the new political, social, economic, and religious consciousness which has engulfed us all. The task is gigantic, but I feel sure that the teachers will rise equal to the task, if governments undertake to train them for the purpose

of discharging their obligations to the future citizens of the country. The problem has been kept hanging for a long time. It cannot wait any longer for a solution. It must be taken up at once by all those who have the best interests of their country at heart.

Section of Psychology.

Abstracts.

1. Laws in Psychology.

S. C. Mitra, Calcutta.

What is a Scientific Law? Are there well-established Laws in Psychology? Consideration of some laws: Weber-Fechner's Law, Jost's Law, Vierordt's Law, Cermak's Law, Laws of Association, and other Laws. Conclusion.

2. Theories and levels of consciousness.

B. C. Ghosh, Calcutta.

(*a*) The meanings of consciousness and its relation to experience and behaviour. (*b*) Its psychological characteristics—its physiological bases—its physical contrasts and analogies. (*c*) Theories: ancient and modern: static and dynamic. (*d*) Levels of consciousness—sensation level; perceptual, conceptual, and intuition levels. (*e*) The unconscious—older views—views of psychoanalytic schools—hormic and gestalt standpoints. (*f*) Antagonisms to the concepts of consciousness—similar antagonism to purpose.

3. The inadequacy of Electra Complex in explaining human life.

Satyananda Roy, Calcutta.

(*a*) The myth of Electra and the doom associated with it. Its significance from the Non-Freudian point of view. (*b*) The Electra Complex as developed by the Freudians and its counterpart the Oedipus Complex. The Freudian reading sex into domestic and social relationships not based upon facts, but on a generalization arrived at by universalizing a particular. (*c*) A modern version of Electra Complex as noticed in Eugene O'Neill's play 'Mourning Becomes Electra'—a psychoanalytic play *par excellence*. (*d*) Do we need the help of an Electra Complex to explain human life in one of its very important phases? The answer is in the negative. The Electra Complex does not explain.

4. On the Hindu Psychology of *rasas* and emotions.

M. N. Banerji, Calcutta.

5. An experimental study of certain qualities of the sense of touch.

Satyananda Roy, Calcutta.

(*a*) As long ago as 1886, G. Stanley Hall and H. Donaldson suggested that what the old psychology called Touch was just opening experi-

mental domain of great breadth. The investigators in this field in Europe and America were no more in agreement as regards their findings than in their theories. The classic experiments of Goldscheider and Von Frey in Germany and Henry Head in England did leave room for further experimentation. Psychologists usually accept one of these classic theories or make a compromise as will be evident from a reading of the text-books on psychology. (*b*) An experimental attack was, therefore, thought necessary to investigate the nature of the touch qualities usually called pressure and cutaneous or prick, and also to determine the nature of the distribution of sensitivity in the skin for these qualities. The experimental work was undertaken by the author of the paper in the laboratory of the Clark University, U.S.A., in 1925, under the guidance of Professor John P. Nafe. (*c*) The author's conclusions are: (i) There are no specific spots on the skin that mediate only pain or only pressure; (ii) it is no longer possible for us to accept the classic theories of cutaneous qualities as held by such investigators as Blix, Goldscheider, Von Frey, and their followers; (iii) the fact that any point or any structure can give rise to any report of a touch quality places us in a position where we can no longer adhere to the theory of punctuate sensibility, which points to specific spots for the different touch qualities—at least for two qualities of pressure and pain.

6. The thermal sense.

K. C. MUKHERJI, Dacca.

A theory has been suggested to reconcile the paradox 'cold' and the 'physiological zero' point of temperature.

7. Laughter.

UDAI BHANU BHAIYAJI, Indore.

The paper suggests that laughter is an effervescing of an emotion in a disturbed state of mind. An emotional safety valve is lifted and the noise which is produced by the chattering of the valve is called laughter.

8. Æsthetic perception.

S. C. MITRA *and* R. GHOSH, Calcutta.

What it is—Current theories—Experimental studies of Fechner, Lipps, Prof. L. J. Martin, Miss E. D. Puffer, and Rudolf Schulze. Present work from a new standpoint—the plan of the experiment—influence of age, sex, etc., on æsthetical perception—other conclusions. A tentative new theory suggested—further lines of work.

9. A new concept of primary colours.

S. K. BOSE, Calcutta.

The current doctrine of primary colours and their geometrical representation in the form of a solid continuum are illogical and contradictory to experience. The colour system built partly of finite degree of unlikeness (e.g. Red to Orange) and partly of infinite degree of unlikeness (e.g. Red to Yellow), is to be given up in favour of a system more in keeping with modern mathematical standpoint and unbiased introspective reports. There is no continuous transition from one colour to any other. Mixture conception (e.g. Orange=Red+Yellow) are to be abandoned and a

different mode of analysis to be adopted. The proposed concept of primary colours is in relation to social and environmental influences on vision and is based on biological and psychological considerations. The experiments of Pikler and Dimmick and the views of Troland and Hartshorn have been discussed. The writer's own introspective analysis is in support of the new concept.

10. Application of newly devised tests to find how children of seven years reason.

MISS S. B. GUPTA, Calcutta.

(*a*) An analysis of the situations followed by a description of the relations involved in the tests; the relations involved: (i) Association, (ii) Likeness and difference, (iii) Effect and Cause, (iv) Attribution. (*b*) Analysis of children's answers shows that successful answers can be divided into three groups, viz. (i) decision without verification, (ii) suggestion, (iii) suggestion with explanation. (*c*) Reproduction of the story to find whether the children have really retained and understood the story. Answers are classified as follows: (i) simple reproduction, (ii) explanation, (iii) inability. (*d*) Conclusion—successful children show that there were some definite stages of reasoning arrived at by different children, viz. (i) groping for the true relation and hazarding a hypothesis, (ii) comparison and verification, (iii) selection and perhaps generalization or in the words of Spearman—Apprehension of experience, Eduction of relations, and Eduction of correlates.

11. Learning curve of a mentally deficient child.

S. C. SINHA, Shusang.

The paper reports the results of training a mentally deficient child and studies the peculiarities of the learning curve.

12. Memory and intelligence.

S. S. JALOTA, Lahore.

In the earliest days of 'Intelligence Testing', a test on *memory* was usually included by Binet and others. Later on its inclusion has been discredited by Spearman, etc.

The *common* formula for scoring is 'twice Right-minus-Wrong' $2(R-W)$. It is theoretically held to be useful for eliminating guessing. But, this formula gives a large number of *zero*-scores. This becomes particularly troublesome if the results are to be given in 'corrected' form (Kitson). To avoid the above, the formula was modified as 'twice-Right *minus* Wrong' $(2R-W)$. By its use we have found the following advantages in an investigation of 1,016 students from various High Schools and Colleges at Lahore (1934-35):—

(i) The number of *zero*-scores is reduced to a negligible quantity.
(ii) The average score shows a significant increase. The minimum found was 32·62% nearly.
(iii) The frequency distribution of the scores obtained by this formula, practically assumes the form of the normal curve. The maximum deviation (Pearson's β_2-3) was $-·2111$ only.
(iv) The inter-correlations with the other component tests show a small mean increase (·0379).
(v) The coefficient of correlation with the scores obtained by the use of the *common* formula is very high ($+·98$, $\pm·007$).

Hence, in view of the immense practical advantages, and specially of (v), it is intended that the theoretical (?) superiority of the other formula may be neglected in common practice.

13. A comparative study of measures of intelligence.

P. C. MAHALANOBIS *and* J. C. SEN, Calcutta.

This paper is based on the scores of 1,212 Bengal school children in a group test of intelligence through the medium of Bengali language.

The reliability of the test, age variation of scores, and the distribution of the I.Q. (Intelligence Quotient) have been discussed in three previous papers (Sankhyā: *The Indian Journal of Statistics*, Vol. I, Part I, pages 25–49; Parts II and III, pages 231–244; Part IV, pages 407–426).

The present paper gives a comparative study of the intelligence measure which is defined as the actually observed score minus graduated average score for the same age group divided by the graduated standard deviation for the age group. It is shown that while the average I.Q. differs appreciably with age, the intelligence measure is completely independent of age. The standard deviations of the I.Q. also differ significantly for different age-groups, but the standard deviations of the intelligence measure are sensibly equal to unity for all groups. The advantages of the intelligence measure are discussed in detail.

14. The reliability of a group intelligence test: A new method

S. S. JALOTA, Lahore.

There are many methods for finding the reliability of an Intelligence Test. It is submitted that the present method contains the essential advantages of most of them; besides that it is a labour saving device. Further, it extends the field of investigation, and thus seeks to eliminate the re-testing of the same students.

The method is as follows: The total score percentile ratings are found for adjacent grades. The *form* of the class is supposed to remain the same during successive periods of its growth. Hence, the percentile ratings give us about 20 representative values in each grade. The coefficients of correlation of the adjacent grades give us the reliability value of the test-battery.

A large scale intelligence testing programme was carried out with some 2,400 students from various High Schools and Colleges at Lahore (1934-35)—Tests were given in English to 969 students; and 1,494 students were tested in vernacular (Hindi and Urdu). The reliability coefficients were found to be uniformly high. The minimum in the case of English tests was $(r_{1\cdot2}) + \cdot985$, $\pm \cdot004$; and that for vernaculars was $(r_{8\cdot9}) + \cdot9849$, $\pm \cdot0012$.

15. A statistical study of marks in the annual and test examinations in relation to University results in I.A. and I.Sc. examinations in Bengal.

P. C. MAHALANOBIS *and* D. P. ACHARYA, Calcutta.

This paper gives a preliminary discussion of the correlation between the marks in the annual and the test examinations in a Bengal College in relation to the University results for five years. It is found that students who are placed in the first division in the University examination score significantly higher marks, but the differences are small and not always significant. There is practically nothing to choose between the third division boys and the failed candidates. It is also found that the prognostic value of the annual examination taken one year earlier is practically the same as that of the test examination usually taken only 2 or 3 months before the University examination.

16. The evolution of the Instinct.

N. S. N. Sastry, Mysore.

Life-process and Life-expression are one continuous process. The misleading view that it has to be broken into tropisms, reflexes, instincts etc., to be properly understood, is beset with great dangers since the real significance and nature of the Life-process may be lost sight of. A necessity of recognising the unitary nature of the expression of life is urged.

Tropism being found inadequate to explain behaviour, the reflex concept was used. But this was found inadequate to explain complicated types of behaviour. So the term instinct was used to explain these and other complicated types of behaviour.

The nature of reflex is discussed to show how it can change. The evolution of the so-called instinct from reflex is traced. The determination of the response patterns in which the reflex has to realise itself is shown to be the basis of the origination of the instinct.

The nature of the instinct is discussed with a view to show that the necessity of overcoming the obstacle was the cause for the stepping-on of emotion. The presence of emotion and the play of instinct in ever-changing environment necessitated the presence and co-operation of intelligence.

GENERAL DISCUSSIONS.

Section of Chemistry.

I. THE SCOPE OF PREPARATION OF FINE CHEMICALS IN INDIA.

Opening Remarks by the President.

The absence of any fine chemical industry in India is a great handicap to all the laboratories and other consumers. Striking out an average from the import figures, it is seen that India has been spending annually about 500 lakhs of rupees on chemicals and another 400 lakhs on dyes and colours. Unfortunately, there are no separate figures available for fine chemicals.

Indian researchers in the field of chemistry—especially in organic chemistry—have often to suspend or change the theme of their work for want of the necessary chemicals. There are two main reasons for such a mishap. Firstly, the cost of the chemical may be very high, and secondly it may be that the substance being not a catalogued one, and not stocked for ready sale, may have to be specially ordered. Even when such special orders are placed, sometimes it happens that after a lapse of some three or four months the firms concerned simply report their inability to undertake the preparations. Evidently the delay and disappointment are due to the non-existence of any chemical manufacturers in India. In addition to the chemist researchers, workers in other sciences also require rare and costly organic chemicals.

Great as the needs of researchers are for these fine chemicals, greater are their civic applications. The spread of modern civilization has increased the chemical needs of India. The establishment of modern hospitals and the wide popularity enjoyed by the synthetic medicines, call for an early establishment of a fine chemical industry in this country.

The Preparation Section.

Mindful of these difficulties and necessities, it was thought worth while giving a trial to a scheme of semi-large-scale preparation of some of the necessary costly research chemicals in India, with the hope that if this enterprise proved to be profitable, it might give rise to a national fine chemical industry which India lacks very badly.

The Preparation Section attached to the Department of Organic Chemistry, Indian Institute of Science, Bangalore, was started in 1930. During the first two years of its existence, one assistant with the help of one laboratory bearer used to run the section. With the sustained activity of the section, with its importance and utility being ever on the increase, its staff had been strengthened by two more preparation assistants. Its activities are now confined to two rooms of dimensions 28 ft. × 32 ft., and 22 ft. × 32 ft. Besides preparing almost all the costly organic chemicals, it has proved its usefulness by recovering good quantities of solvents and some other costly chemicals. It has, moreover, maintained a constant supply of anhydrous solvents to the workers of all the chemical departments. It can well be claimed now that the Preparation Section has become an indispensable addendum to the department. No additional apparatus, other than that available in the Institute chemical stores, has been purchased. The necessary water-baths, stills, ovens, stirring and

shaking appliances and other requisites have always been prepared in the departmental workshop.

ADVANTAGES GAINED.

Within these five years, more than two hundred different chemicals have been prepared, some of them in considerable quantities. The advantages gained may be summarized thus: (1) The immediate availability of the chemical quickens the work on hand. (2) The purity of the substance has always been a great satisfaction. (3) Almost all those chemicals have been prepared at a considerably cheaper cost. (4) The existence of such a Preparation Section is of additional instructional value to the students. The low cost of labour is one of the main contributory factors for the low cost of production.

When an experimental scheme, such as the Preparation Section, has to be viewed on a commercial basis, the points to be considered are many. The section, being meant to supply the demand of a few only, has to prepare a limited number of substances in limited quantities; whereas, in a factory, which will have to satisfy the demands from all, the number will run into thousands easily and the quantity may be considerable. It will be possible to run such a series of experiments that the bye-product in one can profitably be utilized in another. A larger number of preparations and a careful recovery and utilization of bye-products will effect much saving of money. In the Preparation Section mentioned here, only glass vessels have been used, but in a factory metallic and enamelled vessels should be used wherever convenient so that loss due to breakages might be minimized. With the help of a good workshop it must be possible to prepare most of the necessary metallic apparatus locally.

The processes as given in literature require preliminary trials, and very often some modifications had to be effected to get the maximum yield. The experience gained in overcoming difficulties arising in the early stages had always been of great help in the subsequent preparations. The chemicals were prepared according to our needs and as we succeeded in almost every case I venture to suggest that attempts to make other chemicals should be similarly successful.

POSSIBILITY OF COMMERCIALIZATION: KODAK HISTORY.

Besides the question of solving the problem of a ready supply of chemicals to the laboratories, the Preparation Section has shown the possibility of a new and necessary fine chemical industry in India. The cost of production has been so low, particularly in the case of highly priced chemicals, that one is led to an assurance of success if the scheme could be elaborated into a commercial scale.

In this connection, it would be worth while reviewing the origin and development of the Department of Synthetic Chemistry of the Eastman Kodak Company of Rochester, New York, which had its beginnings in a similar small-scale laboratory enterprise. For nearly half a century ending with the commencement of the Great World War, Germany was holding the sole monopoly for fine chemicals. With the onset of war the Germans stopped exporting their chemicals. This opened the eyes of Great Britain and America who have since then worked up their chemical resources in such a manner that they are among the world-competitors to-day. During the vacation months of 1916 Professor C. G. Derick of the University of Illinois with his students prepared in his laboratory a number of organic chemicals required for immediate use. This line of work was ably pursued and extended by Prof. Roger Adams and his colleagues. Acting upon the suggestion and with the support of these professors, the Eastman Kodak Company started their 'Department of Synthetic Chemistry' in September 1918. In their first annual report, the Kodak people say that they had incurred a loss of 14,822 dollars. This naturally

damped their enthusiasm; the more so because, the war having come to an end by then, cheap foreign chemicals found an easy way into America once again. Therefore they appealed to the various University authorities and other consumers that unless their products were supported inland, they would better cease preparing them. The appeal was accepted in the right spirit with the result that a department which prepared only 150 chemicals in the first few years has got to-day a list of more than 3,000 useful and rare chemicals in their catalogue.

Now that the efforts of the Preparation Section have proved to be definitely satisfactory, it is desirable that an attempt at commercialization of such a scheme should be made by our capitalists, the Kodak history acting as an additional stimulus. From the experience gathered so far, it can be said that almost all the costly chemicals can be prepared at competitive prices locally even starting with ordinary chemicals imported from Europe. Once a fine chemical concern comes into existence and assures a steady demand for the raw products, need will arise for their manufacture. Not until then will the outpouring of money in exchange for foreign chemicals stop in India. The disparity of cost between an ordinary chemical and one marked 'reagent' is very big. The unemployment of qualified young chemists in India warrants that preparation and standardization of reagents, and purification of crude imported chemicals for medicinal and analytical purposes, locally, would be profitable. The present problem of unemployment among graduates in science has been used as an argument to say that there is an over-production. But, unlike many of the Arts subjects, chemistry should primarily be meant for application in other spheres than in universities and colleges. With a well-directed move to establish chemical industries in India, the time may not be far off when our universities will have to produce more and more qualified men.

SOME IMPORTANT POINTS FOR CONSIDERATION.

(*a*) The conditions of preparation of fine chemicals are rigid indeed. Strict adherence to specific temperature, pressure, duration and concentration is an essential factor in a successful chemical operation. As the number of chemicals and the processes involved in their preparation are enormous, the fine chemical manufacturer, unlike a sugar or a soap manufacturer, cannot put up a single plant and repeat the same process day in and day out. Every class of preparation will require a particular sort of apparatus set up specially for it, and perhaps sometimes trial runs will have to be made before the right conditions are ascertained. Therefore, skilled labour and highly skilled supervision and the existence of a research section are a few of the essentials for the success of a fine chemical industry.

(*b*) The economics of chemical manufacture lie in the successful recovery and utilization of bye-products. In the preparation and purification of organic chemicals, the use of solvents is very common, the right choice of which for a particular reaction and an expedient recovery of the same should be made wherever possible. Another point for consideration is to select a series of preparations such that the bye-product in one might find some application or use in others.

(*c*) The maximum production for a minimum amount of energy spent should be the motto of every manufacturer, and this can be attained only by a sagacious devising and systematic arrangement of experiments. In organic preparations, one does often come across instances where starting with large quantities of the reactants leads to a very poor or no yield of the product. In such cases, a battery of experiments with small charges should be run simultaneously so that in the end a good quantity of the product is obtained from each unit experiment giving the maximum yield. Many of the operations like distillation at ordinary or reduced pressure, filtration, refluxing, extraction, drying and cooling, etc., being of a mechanical nature do not require constant attention, and one man can look after several operations at a time.

Even in countries where a fine chemical industry has already been well established, the costly research chemicals and synthetic drugs are prepared only on small scales by experts. There seems to be absolutely no reason why similar undertakings should not be successful in our country. The great advantage which India has over other Western countries, in the availability of cheap expert and ordinary labour, should warrant all the more the success of any such chemical venture.

It would be useful to summarize here the advantages to be gained by the initiation of such an industry in India. It would be of great help to Indian laboratories and researchers due to the ready availability of research chemicals in India. Secondly, such an enterprise would create employment for a number of our young chemists. Thirdly, the drain of Indian money would be checked to a certain extent. Lastly, once a nuclear organization comes into existence with the immediate object of meeting the demands of the laboratories, the establishment with its *indispensable research section* could undertake the preparation of other chemicals of general and every-day use in home and in industries, as well as exploit the possibility of utilizing the chemical resources of India.

It is very necessary that we should proceed with caution in any such venture. In an industry like this, none can depend on any external source of information or experience: we have to acquire both ourselves. Like the other advanced countries, we must pass through a preliminary evolutionary period. But this instead of damping our spirit should make us all the more resolute and active. I therefore appeal to our capitalists to utilize the experience already available in this country and explore the possibility of starting industries in this line.

I cannot conclude these remarks better than by quoting Sir P. C. Ray on this subject:

> 'The claims of both pure and applied science are paramount in India as in any other country. . . . Every country in the world has need of both; no country can do without either. India is just now on the threshold of a political renaissance and no political renaissance is possible without the full development of the intellectual and industrial resources of the country. India, therefore, must not only give her full attention to the cultivation of pure science but equally great attention to applied science.
>
> 'There is no lack of capacity amongst our young men. What are wanted are patience and tenacity of purpose.
>
> 'The youth of India will no longer tolerate to be told that he lacks this and lacks that. The fire of life is burning in him. It requires a guiding impulse and a helping hand to lead him on the right path of industrial progress.'

APPENDIX.

List of chemicals prepared.

Hydrocarbons.—Amylene, 1:2-Dimethyl*cyclo*hexene, Diphenyl, Diphenylmethane, Terphenyl.

Alcohols.—1:2-Dimethyl*cyclo*hexanol, Ethylmethylcarbinol, γ-Methyltrimethylene glycol, Tetramethylene glycol.

Halides.—Amylene bromide, Bromacetol, ω-Bromacetophenone, *iso*-Butyl iodide, *sec*-Butyl iodide, Carbon tetrabromide, Carbonyl bromide, Chloracetol, Chloro-β-ketobutane, 2:3-Dibromopropene, *pp*-Di-iododiphenyl, 1:2-Dimethyl-1:2-dibromo*cyclo*hexane, Ethyl bromide, Ethylene bromide, *p*-Iododiphenyl, Methylene bromide, Methylene iodide, Methyl iodide, Monochloromethyl ether, Pentamethylene bromide, *n*-Propyl iodide, Tetramethylene bromide, 1:2:3-Tribromopropane, Trimethylene bromide.

Aldehydes, etc.—Acrolein, Aldehyde ammonia, Aldol, Chlor-propion-acetal, Iminodipropionacetal, *m*-Nitrobenzaldehyde, Salicylaldehyde.

Ketones.—Acetyl acetone, Benzoquinone, Camphorquinone, *p*-Diketo-hexamethylene, Mesityl oxide.

Acids.—Acetonedicarboxylic acid, β-Amino-β-phenylpropionic acid, 3-Aminophthalic acid, β-Aminopropionic acid, β-Brompropionic acid, Camphoryl thiocarbamic acid, Dehydromucic acid, Diglycollic acid, ββ-Dimethylglutaric acid, Dimethyl succinic acid, 3 : 5-Dinitrobenzoic acid, Glutaric acid, Glyceric acid, Methylene-di-salicyldicarboxylic acid, Methyl succinic acid, *m*-Nitrobenzoic acid, *p*-Nitrobenzoic acid, *m*-Nitro-cinnamic acid, 3-Nitrophthalic acid, 4-Nitrophthalic acid, Phenylpropiolic acid, Succinic acid, Urethane acetic acid.

Anhydrides.—Glycine anhydride, Phthalic anhydride, Succinic anhydride.

Acid-chlorides.—Acetyl chloride, Adipyl chloride, Benzoyl chloride, *n*-Butyl chloride, Carbethoxy-glycine chloride, 3-Nitrophthalyl chloride, Oxalyl chloride, *p*-Phenylenedisulphochloride, Succinyl chloride.

Esters.—Ethyl -acetoacetate, -acetonedicarboxylate, -adipate, -allo-phanate, -azodicarboxylate, -bromacetate, -bromomalonate, -α-bromo-propionate, -butane tetracarboxylate, -β-chloropropionate, -cinnamenyl-acrylate, -citraconate, -cyanacetate, -*cyclo*hexane-2 : 3-dione-1 : 4-dicarboxylate, -*cyclo*pentane-1 : 2-dicarboxylate, -*cyclo*pentane-1 : 3-dicarboxylate, -*cyclo*pentanone-2 : 5-dicarboxylate, -diacetyl adipate, -*sym*-dibromosuccinate, -di-imido-diacetyladipate, -diketoapocamphorate, -3 : 6-diketo*cyclo*hexane-1 : 2-dicarboxylate, -ββ-dimethylglutarate, -*asym*-dimethylsuccinate, -ethylidene-bismalonate, -glutarate, -glycocollate, -hydrazine-dicarboxylate, -*iso*propylidene malonate, -malonate, -methylene-bis-acetoacetate, -methylene-bis-cyanacetate, -methylene-bis-malonate, -monomethyl-acetoacetate, -monomethyl-malonate, -oxalacetate, -oxalate, -oxalo-diglycollate, -oxaloglutarate, -oxalothiodiglycollate, -pentane-1 : 1-3 : 3-tetracarboxylate, -pentane-1 : 1-5 : 5-tetracarboxylate, -phenyl-azodicarboxylate, -phenyl propiolate, -succinate, -succinylo-dimalonate, -succinylo-succinate, -thiodiglycollate, -trimethylenedimalonate, -urethane acetate, -xanthate. Methyl -adipate, -benzoate, -succinate, -glutarate, *m*-nitrobenzoate, -oxalate.

Amides and substitution products.—Acetanilide, α-Acetnaphthalide, Acetylurethane, Adipamide, Azodicarbonamide, Benzanilide, Carbo-diurethane, Cyanacetamide, Dibenzoyl-tetramethylenediamine, β-Di-naphthylthiourea, Dinitro-dinaphthylurea, Diphenyl thiourea, *p*-Diphenyt-idyl thiourea, *o*-Ditolylthiourea, *p*-Ditolylthiourea, *m*-Dixylylthiourea, Ethylenediurea, Ethylenediurethane, Methylene-diurethane, Oxalyldiure-thane, Phthalimide.

Nitro- and nitroso-compounds.—*p*-Nitroacetanilide, *p*-Nitrodiphenyl, Nitrourea, Nitroguanidine, Nitroso-β-naphthol, *p*-Nitroso-dimethylani-line, Picric acid.

Amines.—Aminocamphor, *p*-Aminodimethylaniline, 3-Amino-1 : 1-dimethyl-Δ^4-tetrahydrobenzene, *p*-Aminodiphenyl, *pp'*-Diaminodiphenyl methane, 9 : 10-Diaminophenanthrene hydrochloride, Methylamine hydrochloride, Naphthylene diamine, Tetramethylene diamine.

Hydrazines and hydrazides.—3-Aminophthalyl hydrazide, Camphoryl-phenylthiosemicarbazide, Hydrazodicarbonamide, Hydrazodithiodicar-bonimide, *o*-, *m*-, and *p*-Nitrophenylhydrazines, 3-Nitrophthalylhydrazide, Phenylhydrazine, Thiosemicarbazide, Tolylhydrazide.

Cyanides.—Ethylene cyanhydrin, Ethylene cyanide, Methylene-amino-acetonitrile, Trimethylene cyanide, *n*-Valeronitrile, *iso*Valeronitrile.

Mercaptans.—Ethylmercaptan, Methylmercaptan, *p*-Phenylene-dimercaptan, Phenylmercaptan, *p*-Tolylmercaptan.

Sulphides.—Methylbutyl sulphide, Methylethyl sulphide, Methyl-propyl sulphide.

Isocyanates and mustard oils.—Camphoryl mustard oil, Carbethoxy-isothiocyanate, α-Naphthyl *iso*cyanate, β-Naphthyl mustard oil,

Phenetedyl mustard oil, Phenyl mustard oil, *o*-, *m*- and *p*-Tolyl mustard oils, *m*-Xylyl mustard oil.

Sulphonic acids.—1 : 2 : 4-Amino-naphthol-sulphonic acid, Anthraquinone-monosulphonic acids, *p*-Phenylenedisulphonic acid.

Phenols and phenolic esters.—C-Acetyldimethyldihydroresorcin, *p*-Aminophenol, *o*-Cresolphthalein, Dimethyldihydroresorcin, Eosin, Fluorescein, Phenetole, Phenolphthalein.

Heterocyclic compounds.—Barbituric acids, Cinchene, Collidine, Coumarin, Ethyl collidine dicarboxylate, Ethyl dihydrocollidine dicarboxylate, Gaureschi-imide, Hydantoin, Phenyl methyl pyrazolone, Urazole.

Metallic derivatives.—Amalgams, Anhydrous aluminium chloride, Calcium ethyl sulphate, Calcium malonate, Copper-acetoacetate, Mg-methyl iodide, Potassium cyanate, Potassium ethyl xanthate, Potassium hydrosulphide, Potassium xanthosulphonate of benzene, Reinecke salt, Sodamide, Sodium ethoxide, Zinc methyl iodide.

Discussions :

Dr. T. S. Wheeler (*Bombay*).—The need for the production of research organic chemicals in India is very great. Frequently the continuation of a research is held up for months while some needed product is being obtained from Germany. It may be possible to pursuade the firms manufacturing pharmaceuticals in India, to undertake the production of a specified list of fine chemicals on the promise of purchase from the research laboratories in India. The firms could also be helped to manufacture other chemicals on which there could be a profit to offset any loss in the research chemicals. This, however, will take time, so it may be better for this Section to ask the Council of the Indian Chemical Society to organize the production of a limited number of important research chemicals in the various University laboratories throughout the country. Each laboratory could be asked to undertake the production of say three chemicals for the whole of India.

Dr. N. R. Dhar (*Allahabad*).—It is absolutely certain that there is plenty of scope for the manufacture of fine chemicals in this country. Many countries which used to depend before the war on Germany have become self-supporting in the matter of manufacture of fine chemicals during the last fifteen years.

A properly trained chemist was earning about Rs. 150 per month by purifying by recrystallization the ordinary bazar chemicals, e.g. cupric sulphate and selling them to the schools and colleges in the United Provinces. A small firm in Allahabad is selling colloidal and vitaminous products to the extent of Rs. 30,000 per annum. There is no dearth of qualified and well trained chemists in our country but we lack business experience which is of great importance in running a manufacturing concern.

I suggest that a strong committee of the Indian Chemical Society be appointed to work out a practical scheme in this direction.

Dr. J. N. Mukherjee (*Calcutta*).—I had no intention of speaking as my experience of the subject is very meagre. I think, however, that the suggestions which have been made cover too many things and that it would be better to restrict ourselves to the possibility of preparing fine chemicals for meeting the requirements of research workers in India. The question of cost here plays a comparatively minor role. By mutual agreement a list may be prepared and the work may be distributed over the different laboratories which would co-operate in the undertaking. Even here there is an aspect which has been overlooked. The administrative authorities of the institution where the work is being done may like to have information as to the costs of such preparations in case the work is carried out systematically and continuously on a moderate scale. The costing is rather difficult. Besides, the administration may like to know

whether the normal work of the staff engaged is going to suffer. There are therefore two ways open to us : (*a*) to restrict the quantity of the preparations to meet specific requests of colleagues and to notify available stocks accumulated in the normal course ; (*b*) to undertake preparation of specific research chemicals on a large scale to meet possible requirements of research consumption in the country as a whole. This can be undertaken with the approval of the administration. Regarding the broader issue of preparations on a commercial scale to help the establishment of industries, I would suggest that the first step consists in collecting information as to the possibilities and to critically examine them with a view to arrive at definite proposals. The conclusions arrived at, say by a committee, might then be discussed at a meeting of this section in a later year.

DR. R. B. FORSTER (*Bombay*).—Before the preparation of chemicals could be undertaken it was essential to have the necessary supply of starting products. In the case of organic chemicals a very large proportion of these were derivatives of ether, benzene, naphthalene or anthracene and it would be a very great assistance if an adequate supply of these materials were available. Although these substances were termed crude products in industry, the commercial products were however of a very high state of purity. At present they were only imported in very small quantities, usually 1 lb. bottles ; and at a price which rendered their economic use impossible. He saw no reason why the distillation of tar should not be undertaken and importation rendered unnecessary. The manufacture of olein was also essential as the substance was very difficult to transport long distances and was only carried at the shipper's risk.

Failing or pending the manufacture of the necessary starting products in India the difficulties could be bridged over by importation in bulk and repacking in containers of suitable size for dispatch to the parties requiring them. He did not think it advisable at present at any rate, to undertake the manufacture of heavy chemicals such as caustic soda, and soda ash as these were at present manufactured by a few very large concerns having a great deal of accumulated expanses, and further they were sold at keen price and were easy to transport.

In the Department of Chemical Technology of the University of Bombay they had installed plant capable of manufacturing a number of products, and although they did not propose to undertake manufacture on a commercial scale, they were prepared to undertake the trying out on a semi-large scale of the manufacture of products which had been worked out in University laboratories.

DR. N. N. GODBOLE (*Benares*).—Fine chemicals can be manufactured and should be manufactured in India. The greater difficulty is in packing and selling. The market in India is a foolish one and the only thing that counts is a cheap price—no matter what the quality of the goods is like. It is therefore necessary to organize a central body that will certify the quality and purity of the goods manufactured. The dealers who finally sell the goods to the consumer are often ignorant of what they sell and they are interested only in the discount they receive. It will not be possible for the Science Congress to go into the business side. It should however constitute a body that will certify and analyse the standard preparations.

DR. J. N. RAY (*Lahore*).—I am in full sympathy with the views expressed by Dr. Wheeler. It should be possible to arrange the preparation of research fine chemicals with the existing pharmaceutical works. Although it is realized that such ventures may not be financially very profitable in the beginning but if the Indian Chemical Society takes the lead there is no reason to doubt that ultimate means would be achieved. Dr. Forster's opinion that solvents necessary for chemical operations would be too high in cost is not justifiable as in the preparation of fine chemicals, commercial solvents would be unsuitable. The possibilities of exploring new solvents, e.g. furfurol, furyl alcohol, etc. should also be explored.

There is no reason why alkaloids, e.g. ephedrine, emetine, etc. could not be economically manufactured in this country.

It is desirable to have a committee of standards appointed by Indian Chemical Society to help and foster the manufacture of chemicals from indigenous plants.

Professor J. C. Ghosh of Dacca, *Drs. P. C. Mitter* and *A. C. Sircar* of Calcutta also took part in the discussion. There was general agreement and everybody felt the need of starting a fine Chemical Industry in India and the following resolution proposed by Prof. N. R. Dhar and seconded by Dr. J. N. Ray was unanimously passed in the meeting :—

> 'That the Council of the Indian Chemical Society be requested carefully to consider this important question and explore means as to how and on what lines the preparation of fine chemicals can without delay be undertaken in this country'.

II. UTILIZATION OF MOLASSES.

Opening Remarks of the President, Dr. P. C. Guha.

The subject of to-day's discussion has a great bearing on the stabilization and further development of sugar industry in India. With the multiplication of sugar factories and the increased output of white sugar in India, we are faced with the problem of utilization of molasses, the chief bye-product of sugar industry.

An average sample of molasses contains 30-40% of cane sugar, 30% invert sugar (glucose), 2-5% of potash, 2% of lime, 0·5% of phosphoric acid, and about 0·5% of combined nitrogen, the rest, about 15-20% of water. At the present moment about 600,000 tons of molasses are being turned out by various sugar factories in India, which, with all the valuable ingredients, are simply running into waste. It would appear that if all the available sugar in molasses could be recovered, about 400,000 tons of sugar with a selling price of about 10 crores of rupees would be available to the industry.

From the industrial point of view, therefore, the utilization of molasses is a very important problem. While considering the sugar industry, we have to remember that if India has to stand the world competition after 1946, when the tariff protection enjoyed by the Indian sugar industries is likely to be withdrawn, Indian sugar producers will have to lower down their prices to stand the external competition. The success of Indian sugar industry which is the second largest, being next only to textile industry, will largely depend on the proper utilization of this inportant bye-product. Although several methods have been suggested for the utilization of molasses from time to time, the problem has not yet been successfully solved even in great sugar producing countries like Hawaii and Java.

Of the various methods known for the utilization of molasses, (1) the production of power alcohol and its use in association with petrol for internal combustion engines is receiving consideration. Though the problem is attractive, it is beset with several difficulties. Attempts are being made to solve the problem in all its different aspects. As to the extent to which the power alcohol from molasses can be utilized as motor fuel, it has been shown by researches in Germany, France and England that not more than 23% of absolute alcohol can be mixed with petrol for efficient working, which allows utilization of a fraction of the total output of alcohol. Prof. Dhar has also shown that only about 9% of the alcohol possible to be made from all the molasses produced in U.P. can be utilized in that province as motor fuel. It is gratifying to note that the power alcohol produced from molasses is being used at Mysore for trucks along with petrol perhaps as an experimental measure. We will hear more on this subject from Dr. N. G. Chatterjee.

(2) Direct use of molasses as a fuel has been tried in other countries without much success.

(3) The utilization of molasses in a number of minor fermentation industries such as acetic acid, acetone, butyl alchol and glycerine has drawn the attention of scientists. The scope of use and the cost of production of these products under Indian conditions require careful consideration.

(4) Result of investigation carried out at the Indian Institute of Science and also at Coimbatore have shown that yeast extract help the reproductive efficiency of plants. This would suggest that the manufacture of dry yeast from molasses is a promising line of investigation.

(5) The utilization of molasses has been tried in several other directions, amongst which its use as a feed for cattle deserves consideration and is being experimented on at Coimbatore. Its use as a substitute for road tar is also being tried at Mysore.

(6) The utilization of molasses in agriculture as fertilizers is in vogue in Java, Hawaii and other countries. Investigations are in progress at various Indian research centres, viz. at Allahabad, Bangalore and Coimbatore, as to how this can be best applied under local conditions.

A systematic scheme of research as to the effect of molasses on the soil with regard to its physico-chemical and biochemical characteristics and also on its effect on crop production is in progress at Coimbatore and some interesting data have already been collected.

Investigations carried on in an extensive scale in the Allahabad University on the use of molasses as fertilizers have conclusively shown that molasses can be utilized in the fixation of atmospheric nitrogen in the soil--it can also be made to act as a nitrogen sparer. Several other important and useful results have also been obtained there about which we will hear directly from Prof. Dhar.

A systematic scheme of research is in progress in the Indian Institute of Science (1) as to what the fertilizing action of molasses is due ; (2) to ascertain the nature and quantity of the various organic acids produced initially during fermentation of molasses in the soil ; (3) the effect of such acids on the mineral constituents of soil, their availability and effect on plants. Researches are also in progress in order to throw light on different hitherto obscure aspects of the problem.

I have tried just to indicate the various lines of works that are in progress in this country and I hope the discussion now to follow would be of considerable interest. The very fact that the scientific workers are taking a very keen and active interest in this very important problem does clearly show that the scientists in India are quite alive to the importance of the new problem. I hope that their combined efforts will go a great way in helping further development of the sugar industry in India, and the bye-product which is a waste at the present moment might prove to be a source of substantial revenue to the sugar producers of the country. India being an agricultural country, there seems to be very great future open for the utilization of molasses for agricultural purposes. Its utilization as power alcohol is another great avenue, and with the gradual development of other chemical industries in India the surplus of the produced alcohol will find some useful application. It is not unreasonable to expect that as the result of further researches, it might be possible to recover some more of sugar from this important bye-product.

PROF. N. R. DHAR : 'A NEW METHOD OF ADDING NITROGEN TO THE SOIL AND RECLAMATION OF ALKALINE LAND BY USING MOLASSES AND PRESS CAKES.'

POOR CROP YIELD IN INDIA.

It is well known that crop production in India is quite inefficient in comparison with the yield in other countries as is evident from the following figures :—

For *rice* the figures are as follows :—

India	1,295 lb. per acre.
Japan	3,040 " " "
Egypt	2,783 " " "

Wheat.

U.P.	656 lb. per acre.
U.S.A.	856 " " "
France	1,040 " " "
Canada	1,056 " " "
Germany	1,400 " " "
Great Britain ..	1,800 " " "
Belgium	2,104 " " "

Sugar-cane.

India	2,400 lb. per acre
Japan	3,340 " " "
Egypt	3,378 " " "
Java	11,988 " " "
Hawaii	18,799 " " "

The poor crop yield in India is mainly due to the deficiency of nitrogen in the Indian soil, which contains only 0·04% nitrogen as against 0·1% present in the soil of Eurpoean and other cold countries. The Indian soil generally contains plenty of potash, lime, phosphate and other necessary plant food materials.

The researches of Prof. Dhar and his collaborators notably Drs. C. C. Palit, Gopala Rao, A. K. Bhattacharya, Messrs. S. P. Tandon, Atma Ram, N. N. Biswas, S. K. Mukerjee, and E. V. Seshacharyulu have definitely established that nitrogen is added to the soil by the application of molasses. The sugars present in the molasses combine with the oxygen of the air with the help of bacteria, sunlight, and substances like iron, manganese, etc. which are always present in the soil. In this process of oxidation (combination of sugars with oxygen) large amounts of energy are set free and this energy is utilized for the combination of the nitrogen and oxygen of the air forming nitrates and ammonia. Molasses not only adds nitrogen to the soil but also increases its humus content and the beneficial effect lasts over two years.

Prof. Dhar and his colleagues have been able to increase the soil nitrogen by hundred per cent. on the addition of molasses to the soil in heaps and proper aeration. The crop yield has also been considerably increased in the molasses fields in comparison with the controls. Rice is highly benefited by the application of molasses, molassed land producing 14·5 maunds per acre as against 8·1 in the unmolassed field. The straw is also greater in the molassed than in the unmolassed field. Messrs. Parry & Company of Madras and the Government Shahjehanpur Farm have obtained an increased yield of 40% with molasses as manure in sugar cultivation. Moreover the plants mature earlier in molassed fields. Prof. Dhar has made it amply clear that molasses must not be added to the growing crop, but should be added to the fields 2 to 3 months before the sowing of the crop. After the application of the molasses the soil should be ploughed 3 or 4 times before the sowing, watering the soil is just the same as in ordinary cultivation. Prof. Dhar and his collaborators have always found that the moisture content of the molassed-fields is greater than the unmolassed.

In cold countries the soil temperature being low and due to the lack of sunshine, the sugars present in the molasses do not combine with the oxygen easily and hence the energy available from this process is too small for any nitrogen addition to the soil in temperate climates. This is the most important reason why workers in colder countries have frequently failed to obtain beneficial results on the application of molasses. Moreover,

researches carried on in the Chemical Laboratories of the Allahabad University have shown Azotobacter which is one of the agencies in the increase of nitrogen in soil is ineffective at temperatures lower than 10°C., but is very active at temperatures 20° to 50°C. That is why agriculturists in cold countries have not been able to utilize this bacteria in increasing their soil nitrogen. In tropical countries like India, however, Azotobacter is eminently suitable for adding nitrogen to the soil when supplied with molasses, press cakes, etc.

Conservation of Soil Nitrogen by Molasses.

The results obtained by Prof. Dhar and his collaborators with ammonium sulphate added to the soil with and without molasses show that the nitrogen of the molassed soil is always greater than that of the unmolassed one. Hence, molasses can act in the conservation of soil nitrogen. In tropical countries, a mixture of molasses and ammonium salt is a better fertilizer than ammonium salt alone.

Reclamation of Alkaline Land.

The researches of Prof. Dhar and his collaborators show that for the reclamation of alkali soils molasses can be very usefully applied. It is well known that molasses contains between 60 to 70 per cent. of carbohydrates, 4·5% potash, 2% lime, 0·5% phosphoric acid, 0·5% iron and aluminium oxides and 0·5% combined nitrogen and the rest water. Moreover, molasses is distinctly acidic. Research work shows that when molasses is added to the soil, along with carbonic acid organic acids are produced in the early stages in the decomposition and partial oxidation of the carbohydrates present in the molasses. The acids thus produced together with the acids present in molasses neutralize the alkali of the soils rich in alkali. Moreover, the carbonic acid which is produced in large amounts from the decomposition and oxidation of the carbohydrates can convert the sodium carbonate into bicarbonate. Also in the process of the escape of carbonic acid from the molassed soils, the latter is rendered porous and its tilth is improved. The lime, which is added to the soil along with the molasses, is rendered soluble by the organic acids formed from molasses and is helpful in the conversion of the sodium soil (alkaline soil) into the calcium one, which is the normal soil.

The soluble calcium salts are helpful in the improvement of the soil tilth by their flocculating power on the clay particles. Moreover, in the presence of soluble calcium salts, the permeability of the soil is greatly improved. Dr. Dhar and his collaborators show that Molasses is a better reclaiming agent for the alkaline land than either gypsum or powdered sulphur, as there is nitrogen loss from soils when these latter reclaiming agents are added to alkaline soils whilst molasses adds nitrogen. The reclaiming effect of molasses is much quicker than that of gypsum or powdered sulphur, because the acids formed from molasses neutralize the alkali quickly and the soluble calcium salts added with the molasses improve the tilth and permeability of the soil. It has been reported that four years are necessary for reclaiming alkaline lands on treatment with gypsum or powdered sulphur, but with molasses four to six months are quite adequate.

Alkaline lands have been successfully reclaimed in different parts of the United Provinces and in Mysore by the applicaton of molasses, and good crops are growing in these reclaimed areas where no vegetation ever grew.

Prof. V. Subrahmanyan : 'DECOMPOSITION OF CANE MOLASSES IN THE SWAMP SOIL'.

Cane molasses undergoes rapid fermentation under the conditions of swamp soil, the entire quantity of sugar being decomposed in the course of the first few days. The products of fermentation include gases, chiefly,

carbon dioxide, methane and hydrogen; non-acid volatile products such as ethyl alcohol and acetaldehyde; and organic acids, chiefly lactic, acetic, propionic and butyric. Of these, the acids account for the major part of the residual organic carbon.

Shortly after application of molasses, there is increased dissolution of minerals, chiefly ferrous iron and aluminium which are toxic to plant growth. After about a month, however, they are either precipitated or otherwise removed from solution so that healthy conditions are restored.

The nature and extent of dissolution of iron under different conditions have been studied. In alkaline soils, as also those rich in alkaline earth carbonates, only small quantities pass into solution: in others, quite considerable amounts remain in the surface water for about a month. After that period, the iron is partly oxidised to ferric oxide and partly precipitated as the carbonate, sulphide or phosphate.

Although there is some fixation of nitrogen consequent on direct application of molasses to soil, the process involves considerable wastage of organic carbon. There is evidence to show, however, that if the initial fermentation is conducted under conditions of reduced air supply, then the greater part of the sugar will be converted into organic acids. The latter, if applied to the field as their mixed calcium salts, would lead to enhanced fixation of atmospheric nitrogen.

Dr. N. G. Chatterji (*Cawnpore*) discussed the problem from the point of view of the production of power alcohol from molasses, which is certainly the most profitable and useful way of utilizing this bye-product. He produced statistics to show that the surplus quantity of molasses in India would be about 275,000 tons per year, for this would be the quantity available from the total production of about 450,000 tons after deducting 175,000 tons which is the present normal consumption of molasses within the country. In case power alcohol is introduced for the whole of India, practically the whole of this surplus molasses would be required to produce the alcohol required for making the 20:80 alcohol-petrol mixture, the last year's petrol consumption in India being about 81,000,000 gallons. But as there may be difficulties in introducing power alcohol throughout India, it is desirable that it should first of all be introduced in U.P., which are the largest molasses producing area, and are also far away from sea-ports. The cost of manufacture has been very carefully calculated to be within six annas per gallon. There are absolutely no difficulties in technical matters, regarding manufacture, distribution and excise supervision.

Power alcohol manufacture and its use is a matter of supreme national importance for India, now that Burma is getting separated from India. Any replacement of petrol by indigenous alcohol which may be regarded as an agricultural product would mean the saving of so much money from going out of India. Moreover, the increase in consumption of petrol is very rapidly rising in India through no efforts of the petrol industry, and it is but fair that the alcohol industry should share in this increased consumption. It is estimated that for every gallon of power alcohol used, only about an anna would go out of the country, so that from the ultimate national economy point, the use of power alcohol would be much more profitable than the export of molasses. Lastly, by the establishment of the Indian power alcohol industry, the loss in income tax revenue at present derived from the Burma petrol industry, would to some extent be recouped. The only measure which the power alcohol industry wants is an assurance that there would be no cut-in-price competition by its powerful rival industry. This can easily be given by having a minimum sale price fixed for all motor fuels, just as there is now a minimum price for sugar-cane. Such a measure would not only encourage the power alcohol industry but would also give protection to the indigenous petrol industry against the alleged foreign dumping of petrol.

Sir Bryce Burt remarked that, in considering the aid which chemical research and the application of scientific knowledge could give to the

Indian Sugar Industry, undue weight should not be attached to the utilization of bye-products. In many Indian factories there was far more scope for reducing the cost of sugar production by efficient factory operation than through any conceivable way of utilising molasses. Many factories made excessive amounts of molasses and also sent out an entirely unnecessary amount of sugar in their molasses. A comparison of the percentage recoveries obtained by the best and the indifferent factories showed that whilst the former, under Northern Indian conditions, were getting 9 to 9½ per cent. sugar on cane, many factories were getting only 7 per cent. less than this and some as little as 5½%. When it was remembered that the cost of production in some factories was as much as a rupee per maund of sugar higher than it ought to be, compared with the two annas per maund which, under favourable conditions, might be obtained by utilization of molasses, the problem appeared in a different light. The essential requisite at the present moment, for more than half the sugar factories in India, was to maintain a better technical and chemical staff by utilizing the trained men already available in the country. It was no solution of a technical problem to say that Government should give further assistance to an industry or ought to give assistance in a different form to that given at present. The fundamental fact was that petrol without duty and distribution charges only cost about 3 to 4 annas per gallon at ports. Nowhere could alcohol be produced at this figure by the most modern process known.

In the Agricultural Section there had been a very interesting discussion on the utilization of molasses as a fertilizer and that aspect of the subject had also been put before them this morning. There was also the possibility of using it for cattle food. This, in his view, indicated the right line of approach. The final manufactured product sugar was practically a pure carbohydrate and it was right that all possible bye-products should be returned to agriculture in some form or another. He attached importance to experiments to determine the exact conditions under which molasses could profitably be used as fertlizer and on its utilization in the manufacture of cattle foods.

Mr. A. K. Yagnanarayan Aiyer (*President, Agricultural Section*).— It should be borne in mind that in sugar manufactures now universal in India, molasses is a product of some value. The expensive and elaborate arrangements made by the recently formed exporting company, viz. transporting to the rail heads at the different places on the banks of the Ganges, shipping to Calcutta in special tank steamers down the river, extensive storage tanks at Calcutta and ocean Shipment to England, all involving heavy expense go to prove the fact. If it should be worth the while of an exporting company to do all this, it should be much more so for utilization in this country itself for similar purposes, as we could save all the expense, of this elaborate transport. Industrial alcohol will certainly form the most profitable method of utilization, but for reasons of fiscal, administrative, and legislative difficulties the Government of India has ruled this method out; but we have reason to hope that the door is not quite shut and bolted, as in the event of the alternative methods not proving satisfactory the matter may in all probability be reconsidered. Utilization as manure and as a cattle feed presents promising outlets for the product, as India has an abundance of neither the one nor the other and both are also crying needs in the country. Manuring directly for a cane crop has not yielded satisfactory results but if a sannhemp crop is grown as the first crop on molasses manured land a very heavy yield of green manure is obtained which can be ploughed in for cane. This indirect method of cane manuring has been the one found promising in Mysore, as far as present experience goes. The method of application and the difficulties of transport to the fields will prove somewhat serious obstacles. The need for weathering emphasised by Dr. Dhar which should go on for nearly three or four months will likewise constitute another difficulty, as also the very large

doses which he recommends and which in practice are really much too large. For paddy, a one ton dose on alkaline land has yielded good results, and if this should be confirmed by further trials it will provide a very large outlet for molasses, notwithstanding transport and other difficulties. A line of even greater promise is that of making a cattle feed like molasciete, using ground-nut husks and haulms as the filler. Ground-nut will be grown extensively as a rotation crop with cane and very large quantities of these will be available. These bye-products of ground-nut cultivation and the bye-products of the sugar industry will thus be simultaneously made use of in this way, mutually complementing and benefitting both the grower and the manufacturer. At the same time it will give a great stimulus to the improvement of the cattle industry and of dairying by providing a valuable and largely available supply of cattle feed. (The manurial experiments referred to relate to only one season and should be regarded therefore as tentative and not conclusive by any means.)

Sections of Agriculture and Medical and Veterinary Research.

III. 'THE MAKING OF HUMUS FROM AGRICULTURAL AND HABITATION WASTES AND ITS APPLICATION'.

The President of the Agricultural Section (Mr. Yegna Narayan Aiyar) expressed his satisfaction at the enthusiasm of the members of both sections as indicated by the overcrowded hall. He then requested Mr. F. K. Jackson, the Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India and Rajputana, to open the discussion.

In his opening remarks MR. JACKSON pointed out that increasing populations demand a greater production of the right quality of healthy food from the world's limited land surface. The prodigal waste of Nature's bounties must quickly be replaced by efficient conservation. Humus, so essential to soil fertility, is derived from organic matter at present senselessly dissipated by men. India—rural and urban—has yet to realise how much wealth is wasted, when the supply of its humic manures from fields and habitation wastes is left to chance. It is high time that departments of Agriculture and Sanitary authorities should rise to the occasion and follow the example of a few individual workers of the last twenty years in their efforts to bring into current practice, well-tested, practical and sanitary means now available for making humic composts from wastes.

Of the two processes advocated in India, the older, which may be styled 'activated composting'—elaborated by Dr. Gilbert Fowler, differs from the 'Indore process' in the initial building up of a nidus of compost in an active state of fermentation to which regular additions of raw materials are made with simultaneous removal of finished products, the process thus being continuous. Six or seven weekly turns are given and it has so far been applied mainly to municipal wastes. The corresponding Indore techniques, elaborated between 1928 and 1936, specifying three turns to the initial charge and giving ripe compost in three to five weeks from municipal wastes and three to four months from agricultural wastes, claim to be cheaper, simpler and without any disadvantage. Their extreme elasticity has been confirmed under diverse conditions typical of the rain-fed, arid and canal-irrigated tracts, and of sugar-cane, tea, coffee, sisal, cocoanut palm and rubber plantations.

Calculation shows that in India 300 to 400 million tons of humic compost could be made from the organic wastes that are now dissipated.

The crop-producing value of these composts is undoubted and immediate action is demanded to stop such prodigality.

DR. GILBERT FOWLER (*Bangalore*) in his communication pointed out that the Howards were the first to stress the importance of using plant residues only after proper fermentation, which was the reason for the Chinese preference for making compost.

Sewage sludge and towns refuse could now be successfully composted to useful fertilizer.

McCarrison and his school long ago emphasised the beneficial influence of humic manures on the nutritional value of the resulting crop ; thus the close relation of plant and animal life is clearly recognised. Modern researches seem to show that the processes of life to function satisfactorily need a continuous living cycle—micro-organic plant and animal life through which circulates an active constituent—call it vitamin, hormone, or by any other name. Thus the value of compost remains just the same from the days of farmers of 40 centuries ago to those of modern science. Issues of war and peace, determined by food supply, appear ultimately to be dependent on proper utilization of wastes.

DR. N. R. DHAR (*Allahabad*) remarked that compost making is essentially an oxidation by air of carbonaceous materials and proteins, either by themselves or in presence of soil. Such oxidation, until the C : N ratio of 11 : 1 is attained, is the characteristic of the Rothamstead, Indore and Bangalore composts. He had used molasses with the same results ; 50 lbs. of molasses (50–60% carbohydrates) were added to 100 lbs. of soil in heaps, well mixed and occasionally stirred and watered for two months. The low nitrogen and carbon contents (0·04 nitrogen and 0·44 carbon) of northern Indian soils were raised to 0·095% nitrogen and 1·0% carbon respectively. The moisture content was also increased by 3%. Ten to twenty-five per cent. of the total nitrogen becomes available—a much higher proportion than the 1% available nitrogen in soils of colder countries.

The energy liberated by oxidation by air is used by the soil, in fixing nitrogen, just as animals obtain energy from the oxidation of carbohydrates.

DR. V. SUBRAHMANYAN (*Bangalore*) summarised the researches carried out since 1929 at the Indian Institute of Science on (1) ecomomy of carbon and nitrogen during composting, (2) the hygienic aspects of the problem—especially when night-soil is used as a starter.

Town refuse can easily be composted without offence if not more than 200 gallons of raw sewage is daily sprayed per ton of refuse. Disinfectants are effective and result in marked change in composition of microflora. The economy of carbon and nitrogen at each stage is also modified.

Different nitrogenous and mineral starters, combined with raw sewage or effluent from the activated sludge, produced a finished product (1) similar in composition and availability irrespective of the nature of starters, (2) lost about 25 per cent. of nitrogen under aerobic conditions, (3) potash and phosphoric acid did not influence the efficiency.

The difficulty in the manipulation of night-soil compost can be got over by allowing the night-soil to liquefy spontaneously a process starting slowly but quickly gathering speed.

Losses of nitrogen are inevitable. The product is similar to farmyard manure, added superphosphate increases its value.

Night-soil cannot be supplied to the same refuse heaps more than once or twice without the production of offensive smell and fly breeding. Aeration of the night-soil suspension previous to its application reduces the smell without breaking the lumps. Intermittent aeration leads to partial liquefaction and invariable loss of nitrogen.

Highly encouraging results have recently been obtained from experiments on the principle of 'hot' fermentation.

Refuse loosely packed along with nitrogenous starters into cisterns with a moisture-content of about 50%, vigorously fermented within

48 hours with temperature which rose to 75°C. At the end of about a week, cooling began. The material was packed tightly, the tops of the cisterns covered with bricks and plastered with clay. Absolutely no smell or fly breeding was observed. Three months later, a well-disintegrated and pleasant smelling product was obtained, containing over 80 per cent. of the original material and almost all the added nitrogen. This process is being further developed.

LT.-COL. J. R. J. TYRRELL, C.I.E., I.M.S. (Rtd.) (*Indore*) said that while the Indore System is one which requires a certain amount of initial outlay in preparing charging trenches and roads, this outlay will soon be recovered through enhanced receipts from sale of compost and by much-reduced expenditure.

When the simple technique is observed, fly breeding is prevented and it is probable that harmful germs are destroyed.

The sanitary advantages over the trenching system are enormous and these advantages are most marked in the rainy season. If, instead of bringing in a much larger profit, the system cost more than trenching, it would still be justified on sanitation grounds.

By the process, the whole of the refuse of a large city can be disposed of in a sanitary manner daily and in an area one-tenth less than would be required for trenching.

There is a ready demand for the compost. The process is very simple and there is little handling required.

DR. C. N. ACHARYA (*Bangalore*) observed that the further simplifications since evolved of the original Indore process rendered it more or less a method of trial and error and urged the necessity for a more detailed study of the biochemical aspects of the process with a view to control the course of the decomposition more effectively. The hot-fermentation process seemed to secure a greater conservation of dry matter and nitrogen and is worth a more careful study, especially for the disposal of town refuse, in comparison with other methods at present in use in India.

LT.-COL. M. A. NICHOLSON, I.M.S., C.M.O. (*Central India*) remarked that from the point of view of the Sanitary Officer, habitation wastes, containing as they do excreta, are dangerous as well as useless.

The Sanitary Officer has two desires, to render these wastes innocuous as soon as possible and then to get rid of them. To attain these ends he will even adopt incineration, a system admirable as far as he is concerned, as at once and in one process the matter is sterilised and disposed of, but it is a system which I should imagine violates all economic and agricultural principles.

Actual disposal is always a problem to the sanitarian. In London sludge from the sewage works has to be taken out and dumped at sea. A universal and satisfactory method of disposing of the other waste of London has yet to be devised. A great many authorities now use destructors while yet others resort to bringing the heaps *in situ* which is a constant source of complaint and nuisance.

Processes which are good from the sanitary as well as the agricultural point of view are rare, possibly because both sides are working independently and not together. The agriculturist is out to make a super-manure, while the sanitarian will commit crimes such as incineration. From the sanitary point of view I would suggest any process must:

(i) render the waste matter innocuous rapidly;
(ii) be economical to work especially as regard—

(*a*) staff,
(*b*) space,
(*c*) mechanical devices and appliances,
(*d*) transport;

(iii) the matter once sterile must be capable of being got rid of otherwise (ii) (*b*) is violated;

(iv) the process must be simple and this is specially imperative in India or (ii) (*a*) is violated.

The Indore process may not make a manure of a supremely superlative quality. But it does fulfil all the desiderata laid down; above all the cultivator pays to take the final product away and there is so much demand for it that there is no accumulation on the ground with resulting saving in space and staff.

SIR BRYCE BURT emphasised the importance of composts as a means of making up in part for the scarcity of cattle-dung. It was a counsel of perfection to say that dung should not be burnt; often the villager was obliged to use some of the cattle-dung as fuel, but the remainder could be used much more effectively than at present.

MR. YESHWANT D. WAD (*Indore*) said that it appears to be necessary to possess means to choose between composting processes even when they can utilise available raw materials with the existing facilities for space, labour and moisture-supply to produce well-rotted organic matter in sufficient quantities at a cost within the reach of the user and within a period demanded by him.

Properties such as the physical fineness and colour, the content of nitrogen, easily oxidizable organic matter and other components (Table), or the C/N ratio seem to be inadequate.

The ideals for compost-making may be taken as:—

(1) Complete conservation of those existing constituents in the raw materials which are essential both to plant nutrition and improvement of the physical condition of the soil.

(2) Acquisition of additional nitrogen by fixation.

(3) Elimination, during the process of decomposition, of substances unfavourable both to plant growth and good soil texture.

(4) Conversion of useful constituents into such forms as would enable adequate supply to growing plants, whenever required, without losses either during compost-making or after application to soil.

The maintenance of a high level of physical efficiency of the soil should be the primary aim. The capacity to supply nutrients, both as regards quantity and rate, should be secondary and ought not to be increased at the expense of the first-mentioned property.

A compost with a longer residual effect should be preferred, even if its application may not strikingly increase crop-production in the very first season.

Laboratory tests to determine the quality of compost should be able to give information on these points. More information on the properties of soil organic matter in relation to soil fertility appears to be necessary before suitable rapid laboratory tests can be devised. Till then, reliable results can be obtained as a rule only from field trials and from experiments in the laboratory to determine the influence of composts on the nitrogen-balance of soils.

Referring to Dr. Subrahmanyan's description of the 'hot' process recently tried at Bangalore it seemed that the absence of nuisance was due to the offensive gases being confined in a sealed chamber pending their further decomposition. The cost of such chambers and their sealing was likely to be a formidable obstacle to the adoption of the process.

TABLE.

Composition of compost as affected by raw materials.

	Percentages on oven-dry basis.		
	Nitrogen.	Potash.	Phosphate.
Compost from—			
Tea estate wastes:			
Without tipping leaves ..	1·25	1·62	0·32
„ tipping leaf in excess ..	4·70	1·83	0·42
Without wood ash	2·21	0·65	0·62
With wood ash	2·52	1·16	0·69
Without Bone meal ..	2·19	0·39	0·56
With Bone meal	2·05	0·45	1·68
Stable wastes	1·42	1·73	1·40
Cane trash	0·74	0·51	0·35
Habitation wastes	1·56	2·20	2·74

MR. P. B. RICHARDS laid emphasis on the nitrogen content of composts and showed that compost nitrogen is cheaper than ammonium sulphate.

MR. B. N. BATHAM (*Cawnpore*) observed that the percentage of nitrogen found in compost is always greater than 1 per cent., while in cow-dung manure it is always less than 1 per cent. This superiority in the nitrogen content of compost appears to be due probably to the process of nitrogen fixation, which might be going on in the heap of kachra on account of good aeration and oxidation of organic matter.

A comparative trial of molasses, cow-dung and compost as manure for wheat was carried out at Cawnpore. The results show that molasses does not give as high yield of wheat as cow-dung manure or compost, but the residual effects of molasses and compost on the yields of subsequent crop (sunn hemp) was found better than that of cow-dung manure, indicating thereby that their beneficial effects persist for a longer time than those of cow-dung.

After the harvest of the crops from soils manured with molasses as well as untreated, the nitrogen content was higher in the former than the latter. Nitrogen fixation seems to have been encouraged.

THE PRESIDENT, in winding up the Symposium, referred to the thorough and comprehensive manner in which the subject had been dealt with. At one end came the purely sanitary aspect of the matter in which the problem was one entirely of a convenient method of disposal. The medical section had naturally emphasised this aspect of the problem and had drawn attention to the practical difficulties of finding enough storage room in the vicinity of cities for the daily accumulating material without detriment to the health of the neighbourhood, the menace of flies, the need for the handling of the material frequently a disgusting enough work in all conscience—and had pointed out the advantages of the incineration method. At the other end came the agricultural aspect of the matter, the necessity of utilising an admittedly valuable manure in a country like India where it would be almost folly to allow it to go to waste as is being done now. The process of converting the material into an unobjectionable form suitable for convenient handling and transport on a sufficiently large scale assumes then a business character to the municipalities concerned and the element of profit and loss begins to enter into the question. At present only haphazard middle courses were, what were being followed, in which the sanitary aspect generally predominated.

The demonstration in the morning of the Indore process should certainly have been of great interest to all the visitors as it was to him personally. That in the course of the first four days itself in the heap the material should cease to be offensive is a very striking fact indeed. This and the freedom from flies will be the chief features in favour of the method. It is also easy to see that by distributing the compost centres in two or three parts of the town, the difficulty of large storage space, which is a real one, can be overcome. In contrast with the method adopted in Mysore, however, the material turned out in Indore in the stage in which it was seen this morning is both coarse and wet but very much cheaper. The Mysore material is much drier, is free from coarse large particles and is in a powdery condition looking almost like a heap of dark coloured earth. To that extent it should be considered richer and better fit for handling and transport. In Mysore, use is also made in the composting process of the sewage of the city. This is likewise an important feature as the tendency in all modern towns and cities is to instal watercloset systems and a method which will simultaneously utilise both town wastes and sewage will be the one most suitable.

The Mysore compost is being used with advantage largely as manure for sugar-cane fields on the Government and the Sugar Company's Farms as stated in the Presidential Address. With more propaganda its use may extend to ryots' fields and for other crops. The question of cost however is an important factor if its use should extend and we seem to be up against a real difficulty in this regard, because it is very difficult to reconcile the desire of the municipalities to see no reduction in their receipts from the sale of city wastes and that of the cultivators to get the compost cheap. The Indore price of four annas a ton is exceedingly cheap and almost unbelievably so compared with Mysore. If both here and elsewhere the stuff can be prepared for sale at or about this price, it will be taken up most readily by ryots; in fact the supply may not be equal the demand; and the problem from both the sanitary and agricultural view-points will have been solved in the most satisfactory manner.

Mr. F. K. Jackson (*Indore*) expressed doubt whether the use of molasses as described fell within the definition of 'the making of humus', the lignin predominant as a source of soil humus being absent. The discussion had emphasized the immense importance of utilising wastes by composting and had enabled a comparison of existing methods and consideration of future possibilities. He explained that the Indore habitation waste compost which delegates had seen was only about 21 days from the charge. Its innocuous nature at that stage satisfied the medical authorities and the demand from cultivators seldom allowed fully ripe compost to be sold.

Sections of Medical and Veterinary Research and Physiology.

IV. THE PROBLEM OF NUTRITION IN INDIA.

A symposium on 'The Problem of Nutrition in India' was held in a joint meeting of the Physiology and Medical Sections held under the auspices of the Indian Science Congress.

Dr. W. Burridge was in the chair. In opening the discussion he pointed out that the nutritional standards fixed by Voit and others for Western people were not rigidly applicable to India. He said that the basal metabolism and caloric requirements were distinctly lower than in Western countries and due note should be taken of this fact in deciding upon dietary standards in India.

Dr. W. R. Aykroyd referred to common diseases like stone, night-blindness, etc., prevalent in India, which are connected with faulty nutrition.

He discussed the analogies and differences between human and cattle stone and experimental stone in rats and suggested that vitamin A-deficiency might be a causative factor in the production of stone. He said symptoms of vitamin A-deficiency were quite common among childern in southern India. He pleaded for greater co-operation between nutrition research workers, agricultural experts, statisticians and economists.

DR. H. E. C. WILSON pointed out the importance of obtaining dietary standards for Indian populations. Data obtained from orphanages in Calcutta, he said, where diets were poor, when compared to the European standards, did not appear to be associated with a proportionate amount of ill-health. Measurements of the A.C.H. (arm-chest-hip) index of nutrition indicate that children in an orphanage are 50%, while those in a better class school 12% below par. As a general measure increased consumption of milk was advocated.

DR. B. C. GUHA pointed out that although typical deficiency diseases might be relatively rare, the vast majority of the Indian population were living on a subnutritional level, which would inevitably undermine their powers of resistance. This question of affording optimum nutrition to the people had assumed prime importance throughout the civilized world and mere absence of typical disease was no longer considered a sign of optimum health. A survey of the incidence of malnutrition in India was necessary. A detailed survey of the nutritive values of Indian food-stuffs and also of the deficiencies of Indian dietaries had been taken up at the Indian Institute for Medical Research at Calcutta and many useful observations of the particular nutritive values of individual food-stuffs had already been made. It was by relating these different lines of investigation that model dietaries for different categories of the Indian people could be constructed. Proceeding, Dr. Guha pointed out the intimate relations between Nutrition, Agriculture and Public Health and pressed for a close liason between these departments. He pleaded for the adoption of a national food policy for India, which had been so powerfully advocated by Sir F. Gowland Hopkins and Sir John Orr in Great Britain. The policy of *laissez faire* was fatal. Finally, Dr. Guha suggested the formation of a Central Committee for co-ordinating the nutritional investigations at different centres in India.

COL. A. OLVER said that, as the Animal Husbandry Expert, he was deeply interested in the subject of nutrition. He pleaded for more work on the effect of nutrition on disease resistance and the health and development of domesticated animals. He pointed out an example, where blind calves were produced owing to vitamin A-deficiency in the diet of cows.

LT.-COL. H. E. SHORTT said that one should attempt to find a diet for adults, which contained no milk, as, in his opinion, milk was the natural diet of infants only. Dr. Mathur pleaded for a reform in the method of cooking. Dr. V. R. Rajagopalan wished that greater attention were paid to the nutrition of cows, so that the milk produced might not be deficient in essential factors. Dr. B. M. Gupta pointed out the necessity of an accurate chemical examination of all principal food-stuffs, which was overdue. The importance of exercise, light and air was emphasised by Mr. N. M. Basu, so far at least as the problem in Bengal was concerned. In a paper sent by Dr. K. P. Basu he pointed out that in biological value the proteins of green gram were superior to those of lentil.

Finally, according to the suggestion of Dr. B. C. Guha, an 'Indian Nutrition Committee' was set up with the object of co-ordinating nutritional work, that is being carried out at different centres in India. The Committee has been composed of the following with powers to co-opt :—

Mr. N. M. Basu, Dr. B. B. Sarkar, Dr. H. E. C. Wilson, Dr. W. Burridge, Dr. Mathur, Dr. S. N. Ray, Dr. W. R. Aykroyd, Dr. Niyogi, Major Bhatia, Dr. Rahman, Dr. K. P. Basu, Miss Mason, Dr. B. Narayan, and Dr. B. C. Guha (Secretary and Convener).

Section of Geology and Geography.

V. THE CLASSIFICATION OF THE ARCHÆAN ROCKS IN INDIA.

The President in his introductory remarks pointed out that there was no general agreement among the several workers in the Archæan tracts of India regarding the classification and correlation of these ancient rocks stated. This disagreement was in no small measure due to the fact that the scattered occurrences of the Archæan rocks were so widely separated, that it made it almost impossible for any single field geologist to get a personal acquaintance with the typical characteristics of each separate region. Suggesting that such an occasion, when geologists from the various parts of India had met together, formed a most suitable opportunity for a mutual exchange of views on the vexed question, he requested Sir Lewis Fermor who had devoted more than 30 years of his life to an intimate study of many of the Archæan tracts of India, to lead the discussion by giving an account of his views on the subject.

Sir Lewis Fermor opened his observations with a reference to the first part of his Memoir on the Archæans of India, which he said was in the press and would be issued soon. He stated that he had therein divided the Archæans of Peninsular India into two main regions—the Charnockitic and the non-Charnockitic. These two regions were further subdivided into provinces on the strength of geographical position, lithological charact[illegible], and associated ore deposits. Thus, in the non-Charnockitic regio[illegible] subdivisions or provinces, viz., 3 iron-ore provinces of Mysore, C[illegible]-Bastar, and Singhbhum; 3 manganese-ore-marble provinces of [illegible]pur-Balaghat, Narbada-Son valleys, and Rajputana; and 4 igneo[illegible]vinces of Hyderabad, the Satpuran protaxis, Bundelkhand, and th[illegible]ssam plateau, were grouped. In the more highly metamorphic Charnockitic region, 8 provinces were grouped into iron-ore provinces and manganese-ore-marble provinces as before, with the use of an additional criterion the abundance of garnet or otherwise.

Speaking on the correlation of the Archæans, Sir Lewis referred to some of the general features which had been dealt with in his Presidential Address to the National Institute of Sciences of India and also in the Introductory chapter of his Memoir which was in the press. Referring to certain details of correlation, he stated that the recent work of Dr. Krishnan had shown that the Gangpur series of Bihar and Orissa were the equivalents of the Sausar series of the Central Provinces. He regarded the kodurite series as hybrid igneous rocks formed from equivalents of the gondite series, and pointed out the possibility of establishing an acceptable correlation by using the gonditic rocks as a datum line. The Dharwars of Mysore appeared to him to be partly akin to the Sakoli series of the Central Provinces and in part to the Iron-ore series of Singhbhum; and the Sakarsanhalli series suggested a relationship to the gondite series.

The khondalites represented a higher grade of metamorphism, and in the Eastern Ghats province Sir Lewis considered the khondalites to have been formed in a deeper zone than the normal type of Archæans as represented by the Dharwars and to have been subsequently uplifted. To this uplift was probably to be attributed the absence of Purana rocks in the Charnockitic region.

In concluding his remarks, Sir Lewis pointed out the uncertainty of correlating of the Archæans of Peninsular and Extra-Peninsular India.

Mr. D. N. Wadia spoke about the Archæans of the North-western Himalayas. He stated that the Archæan rocks there occupied tracts of northern Hazara, Indus Kohistan, Gilgit, Ladakh and the Zanskar range. The granites and gneisses of those areas were considered by Stoliczka

and Lydekker to be Archæan (Central Gneiss), while the phyllites and schists were regarded as metamorphosed older Palæozoics. McMahon had established the intrusive nature of much of the Central Gneiss and he believed they were of considerably later age, ranging from Palæozoic to Tertiary. Since 1928, the speaker had been working in the crystalline area of the Hazara-Kashmir syntaxis, and the results of his field work tended to prove that the Archæans (Dharwars) of that part of the Himalayas were largely of sedimentary origin. These rocks which had been named the Salkhala series closely resembled the Jutogh series of the Simla Hills. The unconformable relations of the Salkhalas to the Puranas and the fossiliferous Cambrians were observed in some sections. The gneissification of the Salkhalas at many places and the wide prevalence of later intrusive granite-gneiss in the Central axial ranges made it difficult to separate any remnants of the Archæan gneisses in the Complex. The Great Himalaya Range west of Ladakh was found to be largely constituted of the Salkhalas converted into para-gneiss, and the Nanga Parbat (26,620′) massif was almost wholly built of those rocks with intrusive biotite-granite of Palæo-Mesozoic age and hornblende-granite injections of post-Eocene period. South of that range the Salkhalas showed a steadily decreasing grade of metamorphism, and some of the rock elements showed remarkable resemblance with the Dharwar rocks of Rajputana and Singhbhum. Mr. Wadia thought it probable that the Great Himalaya Range represented the basement of the ancient Peninsular Archæans on which the Tethyan sediments were laid down. It thus denoted the Himalayan protaxis.

The speaker said that there were no Archæan outcrops between the Aravalli and the Kashmir Himalayas, except the few straggling hillocks of Kirana and Sangha, which probably represented the unburied peaks of a suspected ridge buried under the Punjab alluvium.

Mr. W. D. West spoke of the difficulty of bringing the Archæans of Rajputana into the 'picture'. Dr. Heron's work had shown that the Bundelkhand gneiss was older than the Aravalli series which represented the lowest division corresponding to the Dharwars. Elsewhere, in Peninsular India, none of the gneisses were definitely established to be older than the Dharwars. There was also some difficulty in fitting the Archæans of Peninsular India with Dr. Heron's classification in Rajputana. If the Sausar series of the Central Provinces were to be correlated with one of the three metamorphosed sedimentary systems in Rajputana on lithological grounds, it was clear that they bore most resemblance to the Delhi system. But the fact that manganese occurred in the Champaner series—which was the same as the Aravalli system—equally well suggested the correlation of the latter with the Sausars, though the two were not alike lithologically. Whether the classifications matched properly or not, the probability of the Aravalli strike in S.E. Rajputana curving round so as to join up with the E.-W. strike of the Central Provinces remained clear.

Mr. West then referred to the Himalayan area and stated that in order to ascertain the age of some of the crystallines in that region by radioactive methods, some specimens were selected and sent to Dr. Dubey. The results of the latter's experiments were yet awaited.

Mr. West also alluded to Mr. Auden's work in the Himalayas, which had shown evidence of an Aravalli strike.

Mr. D. S. Bhattacharjee spoke on his recent work in the East Bhandara district, C.P., which disclosed certain interesting features and which were very suggestive to him in solving the problem of the classification of the Archæans of India. Mr. Bhattacharjee stated that the tract was bounded by rocks with the three regional strikes, viz., the Satpura, Eastern Ghats and Godavari strikes and itself showed numerous evidences of balancing of the directed pressures responsible for these strikes. In the deeper vertical zones of metamorphism, granite-like rocks with what could be described as 'triangular' foliation were developed; while in the

higher zones, foliated rocks closely resembling the Sausars, Sakolis, Cuddapahs, etc. were found. According to him, those rocks were mere metamorphic variants of one and the same group of rocks involved in different proportions and altered under different conditions at different periods of time.

The speaker thought that the study of the Archæans of India had so far been almost wholly confined to belts characterized by effects of singularly dominant directed pressures and that was probably the reason for the general disagreement of the various investigators on the method of classification of these rocks. It appeared to him very likely that when the large tracts outside those belts would be examined, many zones of balanced directed pressure might be found and that the study of such areas might throw more light on that highly controversial subject.

Mr. M. B. Ramachandra Rao spoke of the metamorphic rocks of the Sakarsanhalli area (in Mysore) which had figured rather prominently in the correlation of the Archæans. The results of detailed mapping and examination of this belt had already been published in a Bulletin of the Mysore Geological Department. The rocks occurred as small included patches and lenticular bands along with the hornblende-schists, in the intrusive granitic gneisses, and the speaker was indebted to the President of the meeting for having suggested a possible stratigraphic sequence which could be deduced from the geological section given in the Bulletin referred to. According to that view, the metamorphic rocks of Sakarsanhalli appeared to dip underneath the hornblende-schists, but whether the stratigraphic relation could be actually established or not was left entirely to future work.

Regarding the correlation of the rocks with the gondites, the speaker said that nothing further could be definitely stated. The manganese garnet of Sakarsanhalli had raised some discussion and had been commented upon by Sir Lewis Fermor who showed its relationship in composition to the garnets from the gondite-kodurite series. Originally, the analysis of the Sakarsanhalli garnet had been interpreted rather differently since it was neither so highly manganiferous as the gondite garnets nor so highly calcic as the kodurite garnets. The CaO in the particular specimen had been treated as rather exceptional but the comparison instituted then had no implication of correlation. However, subsequent to Sir Lewis' paper on the Manganese-Lime series of garnets, the speaker was engaged in studying some of the published analyses of many garnets from various parts of the world and the inspection of those analyses had shown him that a few of the garnets from extra-Indian localities could easily be shown to lie within the gondite-kodurite garnet field plotted in Sir Lewis' diagram, though the typical manganese-lime series appeared to be rather rare outside India. The subject was under further investigation and he hoped that Sir Lewis' view regarding the importance of the peculiar metamorphic associations in correlation problems would ultimately prove possible to be established.

Dr. S. K. Roy remarked that Sir Lewis' suggested classification of the Archæans into two main regions and their further subdivisions was most interesting and hoped that further investigation by Indian petrologists would prove the validity of Sir Lewis' classification. The speaker, with his staff and students of the Indian School of Mines, had carried out some detailed mapping and petrological investigations of the Dharwars round the Jharia Coal Field and the Mica mines of Kodarma during the past eight years. Those areas were however 'little' in comparison with those with which Sir Lewis or Messrs. Wadia, West or Rama Rao were acquainted with and on the experience of which they had based their classification. But, so far as the work carried out by the speaker and his associates was concerned, they had found Grubenmann's system of classification and general nomenclature of metamorphic rocks quite satisfactory. Grubenmann had proposed to group the Kristallinenscheifer into twelve groups, while Sir Lewis grouped the Indian metamorphics

into 18 provinces. Grubenmann's classification was followed nowadays in many parts of the world and the speaker believed that although the 18 groups of Sir Lewis showed individual provincial characters—which were of course, somewhat different from what was usually understood by the provincial characteristics of igneous rocks—ultimately many of the rocks of those provinces might be fitted up with Grubenmann's classification. The speaker thought, for that purpose, careful chemical analyses, calculation of the Niggli values of those analyses and the projection of their various ratios on the Niggli-tetrahedrons, were necessary. Those data would not only determine the original igneous or sedimentary nature of the rocks but also the positions of the latter in Grubenmann's scheme would be made clear.

As suggested by Sir Lewis himself in his Presidential Address to the National Institute of Sciences, Dr. Roy thought it would be better to follow as far as possible Grubenmann's classification of the metamorphic rocks to classify the Archæan rocks of India with, however, occasional modifications to meet the local needs.

Sir Lewis Fermor then replied to some of the questions which had been put to him. In reply to Dr. Roy's remarks, he stated that his classification of the Archæans into the Charnockitic and non-Charnockitic regions and their further subdivision into provinces were based on a different conception altogether and had no specific relation to Grubenmann's scheme.

The President thanked the several speakers for their valuable contributions to the discussion and concluded the proceedings with the following remarks:—

'The problem no doubt presents considerable difficulties. A good deal of intensive field work in the several regions of Archæan rocks and a careful co-ordination of the results of such work are still necessary before any final solution can be reached. The classification of the Archæan tracts into provinces and sub-provinces based on mineralogical constitution and the association of epigenetic ores will undoubtedly help to split up the complex formations into convenient sections, but for purposes of correlation of the different isolated formations, it will have to be verified and supplemented by intensive petrogenetic studies of many of the apparently allied types. The correlation of disconnected formations of Archæan rocks of widely separated areas on the basis of the occurrence of any particular lithological type as a recognisable datum line is not always reliable. But still, in the case of the Archæan rocks several clues will have to be followed and the publication of Sir Lewis' Memoir will be eagerly awaited by all students of Archæan Geology to see the lead he gives for amplified application of his line of study.

'Mr. Bhattacharjee's startling inference that the granitic rocks with 'triangular foliation' and the rock groups described as the Sausars, Sakolis and Cuddapahs in the Central Provinces, are the resultants of directed pressure of one and the same mass of granitic material along different zones in a vertical column is not likely to find favour with other geologists acquainted with the region. It is not unknown that in the Archæan Complex, rocks of different modes of origin, involved in various processes of alterations have been rendered almost alike to outward appearance, and the task of the field geologist is, if possible, to sort them out from such confused jumble. In the Archæan complex of Mysore, which had been believed till now to have consisted almost entirely of igneous material, rocks of clearly recognisable sedimentary features are being traced and therefore considerable caution will be necessary before any extreme views could be formulated regarding the genesis of these complex formations. Attempts have been frequently made to classify the Archæan rocks into different groups based on lithological characters, but the question as to how far the crystalline schists as exposed in the several parts of India could be constituted into separate stratigraphic

divisions in each of such regions, on the recognition of reliable evidences of break, seems to me to merit further detailed investigation. This involves a more intensive field study of the several exposures of conglomerates which might be found in the different regions of the Dharwar schists. I have already stated in my address that in Mysore from amidst the confusing types of 'conglomeratic rocks' of diverse modes of origin, two clearly marked horizons of what could be regarded as *basal* conglomerates are recognisable in the belts of Dharwar schists. The older set is characterized by the occurrence of pebbles of only quartzites whereas the younger contains in addition pebbles of granitic rocks, suggesting thereby the probability of some of the granites being really older than a section of the crystalline schists which are all at present grouped as one unit.

'This fact of the probable existence of a granitic series older than a section of the crystalline schists included under the Dharwars, leads me to offer a few remarks on the still controversial stratigraphic position of the Aravalli and the Delhi systems in the Archæan rocks of India. I am personally unacquainted with much of these formations and if I venture to offer any remarks they may be regarded more as suggestions than as positive statements. The Aravallis of Rajputana and the Champaner series of Gujerat seem to be now regarded as of one and the same formation. When I had an opportunity of making a hurried study of the latter as exposed in the southern parts of the Bariya State, I got the impression that portions of the Champaner series resembled very much in appearance the rocks of the 'upper division' of the Dharwar schists of Mysore, and also that the quartzites and shales exposed further north forming a major portion of the State bore an extraordinary striking resemblance to the recorded descriptions of the Idar Quartzites and Phyllites of Mr. Middlemiss, and parts of the Delhi Quartzites of Dr. Heron. Between the typical Champaner beds and those quartzites there is a zone of conglomerate which at the time when I examined seemed to me to be autoclastic, but whether it is so or not needs verification by closer investigation and detailed mapping. At any rate, in that region, the typical Champaner beds come in contact with the series of quartzites and shales or phyllites, comparable in character to the types described as forming parts of the Delhi Quartzites. All these formations bear a close resemblance in their lithological character to corresponding types of the middle and the upper divisions of the Dharwar schists of Mysore in accordance with the classification I have tentatively proposed in my address. On the strength of the occurrence of a series of granites older than a portion of these crystalline schists, it would be a point for consideration, if parts of the formations now classified as Aravallis, Champaners, and the Delhi quartzites, may not correspond to the 'upper division' of my classification of the Dharwar schists of Mysore.

'Let me also say a few words regarding the Sakarsanhalli series of Mysore. This series seems to have attained more prominence for purposes of correlation than the actual facts warrant. The Sakarsanhalli rocks form a series of a few insignificant outcrops scattered about in the granitic gneiss, and however interesting they may be from a petrographic point of view, they furnish very little data for purposes of a reliable correlation. The question of their origin, whether they are merely the metamorphosed facies of the Kolar hornblendic schists of igneous origin, or whether they constitute thermally altered representatives of an assemblage of a mixed series of sediments, may be taken as still unsettled. The occurrence of manganiferous marbles in the series has suggested its alliance with the gondite series of the Central Provinces. Manganiferous dolomites and limestones are found further west of the Sakarsanhalli area in the 'middle division' of the Dharwar schists, and in some parts where the rocks are thermally metamorphosed manganese silicates are also found developed in such limestones. The Sakarsanhalli limestone shreds with their manganiferous silicates may perhaps represent the remnants of a once

continuously folded series of limestones, but reliable evidence is still lacking to prove this conclusively.

'For a successful solution of the problem of the correlation of our Archæan rocks I think it is necessary, for each large area where they are typically exposed, to record how far it is clearly possible to classify the schists into different divisions on probable stratigraphic breaks, and when this has been done, to arrange for a joint investigation of such typical areas by a small body of experienced field geologists consisting of individuals representing the regions on which they have unquestionable knowledge.'

Sections of Botany and Zoology.

VI. BIOLOGY TEACHING IN SECONDARY SCHOOLS.

K. A. PATWARDHAN, Indore.

A meeting of the combined sections of Botany and Zoology was held again this year, during the 23rd Session of the Indian Science Congress, on the 7th of January, 1936, in the room of the Botany section to discuss 'The teaching of Biology in secondary schools'. This question was already discussed last year at the Calcutta session and it was then postponed to be taken up again at the Indore session. Mr. Patwardhan opened the discussion and put forward an outline of the views he held in the matter. He was also able this year to put up his scheme about making it possible for the syllabus to be incorporated in the teaching curriculums of schools. The question was then placed for the discussion of the body. The body was of opinion that a complete revolution in the methods of education was necessary at the present time and it seemed to be generally recognised that it would be well if systematic instruction in science formed an integral part of the school work. The result of the discussion may be summarised thus:—

(1) The best preparation for any profession or occupation was a *general education* up to the stage reached by an average boy at the age of say 16 to 18.

(2) This general education should provide normally for the study of English, Vernacular, History and Geography, Mathematics and *Natural Science*.

(3) Systematic instruction in Natural Science should thus form a *compulsory part* of the general course of education in every secondary school.

(4) The present science curriculum (this is one of the optional subjects at present) in practically all schools consists of a laboratory course in Physics and Chemistry. That these two subjects will form the main parts of the science syllabus but this does not mean that boys should leave the school with the idea that science consists of Physics and Chemistry alone.

(5) Hence the study of Biology, being pre-eminently a study natural to boys and girls, should also be an integral part of the compulsory science course.

(6) That this course in science should not be planned as if the main object was to lay the foundation of a specialised study at a later period. (This is the state of affairs now.)

(7) The course in compulsory science, therefore, for boys and girls up to the High School-stage, should be self-contained and designed to give special attention to those phenomena which are matters of every-day experience and as such, closely allied and connected with the daily needs of life.

Before putting up the above views of this body for the consideration of the Executive Committee of the Indian Science Congress Association for further action it was deemed necessary that the conditions as they exist to-day in the different provinces in India be first examined and scrutinised and then definite recommendations be put forward to the Executive Committee to enable them to take further steps in the matter. A sub-committee was therefore appointed, on the spot, consisting of the following members representing different Universities. This committee was given full powers to co-opt more members to enable it to complete the work and get its report ready for the next session of the Indian Science Congress to be held at Hyderabad in January 1937 :—

1. Dr. B. K. Das, D.Sc. (London), Professor of Zoology, Osmania University College, Hyderabad (Deccan).
2. Mr. M. C. Sethi, M.Sc., Professor of Botany, Forman Christian College, Lahore.
3. Prof. N. K. Tewari, M.Sc., Botanic Department, Benares University, Benares.
4. Dr. F. H. Graveley, D.Sc., F.A.S.B., Superintendent, Government Museum, Museum House, Egmore, Madras.
5. Dr. H. K. Mukerji, M.Sc. (Cal.), D.Sc. (London), Head of the Department of Zoology, Calcutta University, Calcutta.
6. Dr. S. K. Pande, D.Sc., Lucknow University, Lucknow.
7. Dr. C. B. Rama Rao, B.A., M.D., President, Natural History School, Bangalore.
8. Dr. M. K. Gupta, D.Sc., Beawar College, Beawar (Raj).
9. Mr. K. A. Patwardhan, M.Sc. (Secretary of the Committee).

It is proposed that the following members be co-opted :—

1. Dr. Y. Bharadwaj, M.Sc., Ph.D. (Lond.), Professor of Botany, Hindu University, Benares.
2. Dr. T. Ekambaram, M.A., Ph.D., Presidency College, Madras.
3. Dr. E. K. Janaki Ammal, M.A., D.Sc., Sugar-cane Geneticist, Coimbatore.
4. Dr. B. L. Bhatia, D.Sc., F.L.S., Professor, Government College, Hoshiarpur.
5. Mr. N. C. Chatterji, B.Sc., F.R.E.S., 7, Rajpur Road, Dehra Dun.
6. Mrs. Sarojini Datta, M.A., M.Sc., Professor of Botany, Bethune College, Calcutta.
7. Dr. J. B. Seth, D.Sc., Department of Physics, Lahore.
8. Dr. Birbal Sahani, D.Sc., F.R.S., University Professor of Botany, Lucknow University, Lucknow.
9. Dr. K. N. Bahl, Ph.D., D.Sc., University Professor of Zoology, University of Lucknow, Lucknow.
10. Dr. Baini Prashad, D.Sc., F.R.S.E., Indian Museum, Calcutta.

A. *What is science ? Is it suitable for instruction in schools ?*

(1) The definition of science.

(2) Which is suitable for the instruction of students in schools—(*a*) The habit of scientific thinking or (*b*) subject matter ? In other words, should it be formative or informational, mind training or mind filling ?

(3) Both are equally necessary and it is the duty of the science master to see that children are provided with a profusion of intelligently organised sensory contacts, and they are directed towards the problem-solving attitude of mind.

B. Why should science be taught in schools ?

(1) Science teaching gives students a new appreciation of their commonplace environments.

(2) Science teaching should make students familiar with the tremendous reservoir of new knowledge which needs but to be applied in the various fields of human endeavour to make them yield a hundred-fold.

(3) Science teaching should teach students the value of scientific thought and impress on them the need of training in such thinking.

C. How should the material be selected for science teaching ?

The principles to be followed :—

(1) The material selected should be inherently interesting to the pupils, and science should be introduced in all schools in the form of nature study which should aim at arousing an interest in animal life, plant life and natural phenomena, and at developing the power of observation.

(2) The topics selected should be of large social value. Therefore topics should be selected from biology, physics and chemistry dealing with large scientific principles, with the way in which these principles are exemplified in familiar phenomena and with their application in the service of man. As the science of biology teaches all parts of social life, we cannot afford to neglect it as we are doing at present.

(3) It should be material that will lend itself readily to the accomplishment of the aims in science teaching. Besides being interesting and of large social value it should be material which will develop the student's powers of weighing and interpreting evidence and thus promote in him the scientific method of thinking.

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A. RULES INDIAN SCIENCE CONGRESS.

At a meeting of the Executive Committee of the Congress held on Friday, January 3, 1936, in the Daly College, Indore, the question of altering rules 13 and 17 of the Indian Science Congress Association regarding the method of electing five members of the General Committee to the Executive Committee and to the Council was considered. Following the suggestions of this meeting the rules were finally amended by the General Committee of the Congress at a meeting held on Monday, January 6, 1936. The revised rules are printed below :

NEW RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including :—

(a) the holding and management of funds and property ;
(b) the acquisition of rights and privileges necessary or convenient for the object of the Association ;
(c) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

4. The annual subscription of Ordinary Members shall be Rs. 10. The subscription shall become due on the 1st February of each year, and shall only be effective as a payment for Ordinary membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all futnre annual subscriptions by the payment in a single sum of Rs. 150.

6. There shall be three classes of Session Members :—

(a) Full Session Members—Subscription Rs. 10 per Session.
(b) Associate Session Members—Subscription Rs. 5 per Session.
(c) Student Session Members—Subscription Rs. 2 per Session.

7. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members provided such papers be communicated through an Ordinary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

8. The official year of the Association shall commence from the 1st of February.

9. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

10. Only Ordinary Members shall hold office in the Association.

11. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

12. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

13. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer (who shall be the Treasurer of the Royal Asiatic Society of Bengal for the time being), the Managing Secretary (who shall be the General Secretary of the Royal Asiatic Society of Bengal for the time being), and five Ordinary Members elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

14. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

15. There shall be a General Committee which shall consist of all Ordinary Members of the Association.

16. The General Committee shall meet at least once during each Session of the Congress preferably in the middle of the Session.

17. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition five Ordinary Members of the Association elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Council. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th

September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

18. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

19. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

20. There shall be two General Secretaries who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

21. The term of office of each General Secretary shall be for a period of five years following the confirmation of his appointment and he shall be eligible for re-appointment.

22. In the event of a vacancy amongst the General Secretaries occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary for the period up to the termination of the next Session of the Congress.

23. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

24. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

25. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

26. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee.

27. There shall be Sectional Presidents and Sectional Recorders who shall be appointed by the Executive Committee.

28. There shall be Sectional Committees which shall consist of the following :—

(a) The President of the Section (convener) ;
(b) The Recorder of the Section ;
(c) All Ordinary Members of the Association who have been President or Recorder of the Section concerned ;
(d) Two Ordinary Members elected by the General Committee at its Annual Meeting during the Session of the Congress.

A Sectional Committee may co-opt two additional Ordinary Members of the Congress of whom one at least shall be resident in the locality in which the ensuing Session of the Congress is to be held.

29. The Sectional Committees shall meet on the opening day of each Session of the Congress and as often as may be necessary during the Session of the Congress.

In the absence of the President of any Section from any of its meeting the most senior member of the Sectional Committee present shall take the Chair.

Each Sectional Committee shall in its meetings during the Session of each Congress :—

(a) nominate a Sectional President and a Sectional Recorder for next year's Session of the Congress for the consideration of the Executive Committee ;

(*b*) determine the detailed arrangements of the Sectional meetings;
(*c*) select the papers to be read and discussed;
(*d*) delete by a two-thirds' majority any abstract from final publication in the Proceedings;
(*e*) determine the contents of the Sectional record in the Proceedings, observing the relevant provisions of Rule 30.

30. (*a*) Any paper submitted for reading at the Session of the Congress shall be forwarded to the President of the Section concerned so as to reach him not later than a date to be fixed from time to time by the Executive Committee.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) Any paper submitted for reading at the Session of the Congress shall be refereed by the Sectional President or by some person or persons appointed by him. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) No abstract shall be published in the Proceedings if the complete paper has not been available for reading before the meetings of a Section.

31. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association :—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds' majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January, 1931.
Revised the 5th January 1935,
and the 6th January, 1936.)

B. INVITATION TO THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

At the meeting of the Executive Committee of the Congress held on January 4, 1935, in Calcutta the question of extending an invitation to the British Association to hold its 1938 meeting in India was considered, 1938 being the Jubilee year of the Indian Science Congress. The sub-committee appointed to consider the matter addressed a letter to the General Secretary, British Association, inviting the British Association to hold its 1938 meeting in India jointly with the Jubilee session of the Indian Science Congress. The Secretary, British Association, wrote in reply that the Council of the British Association received the invitation with great interest, but as it had already been tentatively arranged to hold the 1938 meeting of the British Association in Cambridge, the invitation could not be accepted as such, but alternatively, the British Association would be glad to send a representative scientific party to join the Jubilee session of the Congress in January, 1938.

The letter was considered by the above sub-committee at its meeting on April 12, 1935, and on their recommendation which was confirmed (in circulation) by the Executive Committee, Profs. S. P. Agharkar and J. N. Mukherjee, who happened to be proceeding to England at the time, met Profs. Boswell and Stratton, the General Secretaries and Dr. Howarth, the Secretary of the British Association, and discussed the matter with them. Prof. Mukherjee, who happened to join the British Association meeting at Norwich in 1935, further explained the position at a meeting of the General Committee of the British Association. This meeting accepted the invitation and adopted the following resolution :

'The General Committee consider that it is desirable that the Association should accept the invitation to meet in joint session with the Indian Science Congress Association at the celebration of its Jubilee in the Christmas vacation, 1937-38, and authorise the Council to carry on negotiations with the Indian Science Congress Association to that end.'

This resolution was considered at a special meeting of the Executive Committee held on January 2, 1936 and on their recommendation the General Committee of the Indian Science Congress Association at a meeting held in January, 1936 at Indore, adopted unanimously the following resolutions :

(1) 'Resolved to invite a deputation of scientists from the British Association and elsewhere to meet in joint session with the Indian Science Congress Association in celebration of its Silver Jubilee in January, 1938.'

(2) 'Resolved that the Executive Committee, with power to co-opt, be authorized to take the necessary steps in this connection and to report progress to the General Committee in January, 1937.'

C. MEETINGS OF THE GENERAL COMMITTEE, THE EXECUTIVE COMMITTEE AND THE COUNCIL OF THE INDIAN SCIENCE CONGRESS ASSOCIATION.

C.1. *Meetings of the General Committee.*

A meeting of the General Committee of the Congress was held at 1-45 P.M. on Monday, January 6, 1936, in the Daly College, Indore, with Sir U. N. Brahmachari, General President, in the chair. The following items of business were transacted:

(1) The minutes of the last two meetings of the General Committee held on 3-1-35 and 5-1-35 in Calcutta were read and adopted.

(2) Resolutions recommending certain alterations to rules 13 and 17 of the Indian Science Congress as suggested by the Executive Committee were adopted. These have been reported in Section A.

(3) Resolutions in connection with the question of extending an invitation to the British Association were adopted. These have been reported in Section B.

(4) Ordinary members to the Executive Committee, the Council and the different sectional committees for the year 1936-37 were elected by the General Committee.

(5) The appointment of Rao Bahadur T. S. Venkataraman as General President of the 24th Session was announced.

(6) It was further announced that the 24th Session of the Congress would be held at Hyderabad (Deccan) from the 2nd to the 8th January, 1937.

C.2. *Meetings of the Executive Committee.*

A special meeting of the Executive Committee of the Indian Science Congress was held at 12 NOON on Thursday, January 2, 1936, in the Daly College, Indore, with Sir U. N. Brahmachari in the chair. Resolutions regarding the extension of invitation to the British Association were passed (*vide* Section B).

A meeting of the Executive Committee of the Congress was held at 1-45 P.M. on Friday, January 3, 1936, in the Daly College, Indore, and the following items of business among others were transacted:

The Statement of accounts for the year 1935-36 presented by Prof. J. N. Mukherjee in the absence of Dr. S. L. Hora, the Treasurer, was adopted.

It was resolved to have the accounts of the Congress professionally audited in future years.

Regarding the surplus of the Local Committee's fund it was resolved that in future the Local Committee should be requested to contribute the surplus to a reserve fund of the Association.

It was resolved 'that Rs. 12,000 should be invested in some redeemable loan, the particular loan to be decided by the Treasurer on the advice of the banks'.

Resolutions were passed recommending allotment of a grant of Rs. 600 to the Asiatic Society of Bengal in payment for the work done by the Society in 1936 on account of the work of the Congress and of Rs. 250 each to 'Current Science' for the year *1935* and to 'Science and Culture' for the year *1936* respectively.

Resolutions to be placed before the General Committee were passed suggesting certain alterations of Rules 13 and 17 of the Indian Science Congress Association (*vide* Section C.1).

Regarding the 24th session of the Congress, to be held in January, 1937, invitations from the Osmania University, Hyderabad, and the

University of the Punjab, Lahore, were considered and it was decided to accept the invitation from the Osmania University.

The appointment of Rao Bahadur T. S. Venkataraman as General President was confirmed.

Presidents and recorders of the different sections were elected.

C.3. *Council Meeting.*

A meeting of the Council of the Indian Science Congress Association was held at 3 P.M. on Thursday, January 2, 1936, in the Daly College, Indore. The following among other items of business were conducted:

Regarding the alteration of the method of electing the five members of the General Committee to the Executive Committee and the five members to the Council it was agreed that an alteration was desirable and suggestions regarding the alterations were made.

On the basis of the suggestions received in reply to a letter from the General Secretary regarding improvements in the scientific work of the Congress a sub-committee was appointed to consider the matter and to report to the Council.

Resolutions recommending extension of invitation to the British Association to send a deputation of scientists to join in the Jubilee session of the Indian Science Congress in January, 1938, were passed (*vide* Section B).

ACCOUNTS.

I.

Accounts of the Indian Science Congress Association for the year ending with the 31st December, 1935.

RECEIPTS.	Rs.	A.	P.	EXPENDITURE.	Rs.	A.	P.
To Balance ..	18,916	6	2	By Indexing ..	96	0	0
,, Interest on Fixed deposits ..	450	0	0	,, Contribution to A.S.B. ..	1,000	0	0
,, Subscriptions received a/c Local sales, from Dr. Agharkar and Mr. West ..	857	0	0	,, Contingencies ..	476	9	6
,, Contribution received from Bombay University ..	500	0	0	,, Printing ..	3,552	2	0
,, Life Membership Fee ..	150	0	0	,, Travelling expenses to Dr. Agharkar a/c 21st Session, Bombay ..	251	2	0
,, Return of advances, a/c Printing (Rs.90-7)	90	7	0	,, Postage ..	1,248	6	6
,, Ordinary Subscriptions ..	4,410	0	0	,, Wages ..	59	3	3
,, Subscriptions ..	1,185	8	0	,, Refund of subscriptions ..	20	0	0
				,, Refund of Lt.-Col. O. B. Hill's Admission fee and sub. to the N.I. of S. of India ..	68	0	0
				,, Balance :—			
				In Bank ..	337	13	11
				Fixed Deposits	19,450	0	0
TOTAL ..	26,559	5	2	TOTAL ..	26,559	5	2

S. L. HORA,
Honorary Treasurer,
Royal Asiatic Society of Bengal,
A/c Indian Science Congress Association.

II.

INDIAN SCIENCE CONGRESS, INDORE, 1936.

Statement of Receipts and Payments of the Local Reception Committe

RECEIPTS.

	Rs.	A.	P.
To *Donations* :—			
H. H. Maharaja Holkar ..	4,000	0	0
,, *Subscription* :—			
Members of Reception Committee .	1,277	0	0
,, *Other Receipts* :—			
Sale of Excursion Tickets ..	795	0	0
Sale of Conveyance Tickets ..	396	0	0
Boarding Charges ..	2,064	0	0
Rent of Stalls ..	150	0	0
Advertisements in Guide Book ..	112	8	0
Miscellaneous Receipts ..	23	0	0
,, *Indian Science Congress Association* :—			
Membership ..	863	0	0
TOTAL ..	9,680	8	0

EXPENDITURE.

	Rs.	A.
By Opening Ceremony	134	15
,, Sectional Meetings ..	397	9
,, Microphones ..	383	12
,, Exhibition .	35	0
,, Accommodation ..	385	8
,, Boarding Charges ..	1,900	8
,, Conveyances ..	1,779	12
,, Guide Book .	613	8
,, Musical Soirée ..	250	0
,, Excursions expenses excluding conveyances .	212	2
,, Photographs .	75	0
,, Volunteers ..	301	7
,, Badges ..	86	3
,, Office Establishment	433	0
,, Stationery and Printing ..	476	14
,, Telephone ..	30	0
,, Postage and Telegrams ..	106	11
,, Audit Fees ..	50	0
,, Report of the Session ..	66	0
,, Contingencies (Sundry Expenses)	104	8
,, Subscription of Indian Science Congress Association Membership ..	863	0
,, Balance in current account with the Imperial Bank of India, Indore, to be given as donation to the Jubilee Fund of the Indian Science Congress Association ..	995	0
TOTAL ..	9,680	8

M. G. SALTER,
Hon. Treasurer,
Local Reception Committee.

K. A. PATWARDHAN,
S. S. DESHAPANDE,
Hon. Local Secretari